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Identifying reasons for historic car ownership and use and policy implications: an explorative latent class analysis

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Abstract

The number of historic vehicles is steadily increasing. Although, these vehicles are part of our cultural heritage with respect to road transport and mobility, they present (future) environmental concerns, which is a relevant development from policy perspective. Yet, as far as the authors are aware, there is hardly any academic literature addressing this issue. This study aims to provide a first exploration of historic cars and reasons for ownership and use and policy implications. To this end, a large explorative survey is conducted among HV owners of 15 European countries. Focusing on passenger car owners only, a latent class analysis is performed to identify possible segments among historic car owners. Seven latent classes are identified: recreational owners, reserved owners, repair men, die-hard fans, next generation fans, frequent drivers and collectors. Overall, the results indicate that there is large diversity in the ownership and use of historic cars and the reasons behind ownership. However, in general, historic cars are used much less than modern cars. Only the group of 'frequent drivers' (8% of the sample) represent a potential concern regarding emissions from a policy perspective. Finally, policy recommendations are provided for decision makers regarding historic cars.

Keywords: Historic cars, latent class analysis, environmental impact, policy, car ownership

1. Introduction

Historic vehicles[1] (HVs) form a specific category of transport, either on-road or in preserved off-road conditions that represent a historic era in the evolution of the vehicle industry. HVs are becoming increasingly popular among owners, enthusiasts and also the wider public, which makes the area of historic vehicles relevant from a social, cultural (heritage) and economic point of view (Tam-Scott, 2009).

Based on a broad survey among individual enthusiasts, traders and HV clubs, Frost et al. (2006) conclude that, within the European Union, there are roughly 786,000 club members, belonging to nearly 2000 clubs and owning some 1,950,000 historic vehicles (Frost et al. 2006). In addition, Frost et al. (2006) estimate that over 55,000 people earn some or all their living serving the historic vehicle movement and that historic vehicle related activities are worth over €16 billion to the EU annually. This latter figure refers to the quantifiable benefits of these vehicles and does not include the non-monetary and non-instrumental gains for individuals resulting from owning, repairing, driving and/or admiring historic vehicles.

The number of HVs (1.9 million) accounts for only a small percentage, roughly 1%, of all vehicles registered in the EU (Frost et al., 2006). Furthermore, HVs account for an even smaller percentage (0.07%) of the total distance travelled by all vehicles (Frost et al., 2006). However, the number of HVs can be expected to rise for at least two reasons: a) increasing numbers of cars are being manufactured, globally. Car production has increased from 41 million in 2000 to 67 million in 2014 (Statista, 2015) and b) the average life expectancy of cars is also increasing.

[1] In this paper, historic vehicles are defined as vehicles older than 30 years. Historic vehicles are sometimes called 'classic vehicles', however, we stay with the term historic rather than classic, since latter can entail broader meanings for a vehicle.

For example, in the EU, the average age of cars has increased from 8.4 years in 2006 to 9.7 in 2014 (ACEA, 2015).

While in terms of CO_2 emissions the (relative) impacts of HVs are (still) rather low, older cars are generally more polluting in terms of other pollutants, in particular hydrocarbons, nitrogen oxides and particulate matter (PM). For example, in terms of particulate matter, the emissions (per kilometre driven) of cars manufactured before the introduction of the Euro 1 norm, introduced in 1992 in the EU, may be at least 30 times higher than a new car with a Euro 6 norm (Dieselnet, 2015). Motivated by the goal to improve local air quality, authorities in a number of European cities have implemented regulations to ban older vehicles from their (inner) city areas. These areas are normally referred to as "Low Emission Zones"[2]. However, policies across different countries regarding HV admission to urban areas have not been always congruent. For example, in London, HVs are exempted from paying the extra charges for entering the 'Ultra Low Emission Zone'. Also with respect to road taxation, exemptions for older cars are sometimes made. For example, in the Netherlands cars older than 40 years are exempted from paying road taxes.

Given the relevance of HVs from the perspective of cultural heritage, the economic and non-instrumental benefits to owners and the general public and also (future) environmental concerns for transport policy makers, it is surprising that there is hardly any academic literature addressing this topic.

Moreover, some studies (Steg, 2005; Schwanen and Lucas, 2011) discusses non-instrumental factors such as feeling of sensation or showing status, emotions or even attitudes for car use. However, this mentioned literature mainly considers modern cars and not HVs. Given that HV ownership and use could be an expensive hobby and considering that these vehicles have lower safety and handling performance than modern ones, it is expected that non-instrumental factors play an important role in HV ownership and use, which requires further exploration.

The primary aim of this study is to provide a first exploration on the policy issues regarding pollution caused by historic cars[3] and in addition, investigate the non-instrumental factors influencing ownership of such cars. These two objectives are approached empirically, in this study. Specifically, we aim to answer the following questions: What kind of people own historic cars? How many cars do they own on average? To what extent do they use their car(s) for regular transport (and thus contribute to air pollution)? What are their motivations to own historic cars? To what extent are they member of HV clubs? To what extent are they engaged in attending historic vehicle events? How much do they spend on the ownership and maintenance of their cars? Which non-instrumental factors are relevant for historic car use and ownership? The answers to these questions provide some indications on the role of non-instrumental factors in owning and using historic vehicles as well as an assessment of the extent in which historic vehicles (indeed) represent a relevant target group for environmental policies.

To answer the formulated research questions, a large survey is conducted among HV owners of 15 European countries. Using the data from this survey, we apply an explorative probabilistic clustering technique, namely latent class analysis (Vermunt & Magidson, 2002), to identify distinct segments in the population of HV owners. We use the total mileage on historic passenger car(s) and other indicators to reveal the shared characteristics of each latent class.

[2] These areas can be found at the official website affiliated to EU commission: http://urbanaccessregulations.eu/

[3] In this study, we will consider historic passenger cars rather than all types of HVs, since they are by far the most common type of historic vehicles.

The environmental impacts of HVs form the main concern for policy makers in terms of setting regulations in use or restrictions on HVs. Therefore, we use the annual mileage as an approximate determinant of the pollution emitted by HVs

The remainder of this paper is structured as follows. In section 2 we provide a brief literature review on the topic of HVs. Section 3 discusses the method and data and section 4 presents the outcomes of the latent class analysis. Finally, section 5 summarizes the conclusions and discusses several policy outcomes and practical implications.

2. Brief literature overview

As mentioned in the introduction, the literature on motivations of HV ownership is scarce. As far as the authors are aware, there are only a handful of papers addressing the topic of historic vehicles. They generally adopt a qualitative research methodology and focus on the question why owners are so passionate about their historic cars.

One of the earliest investigations is the study of Dannefer (1980). Dannefer adopts a sociological approach to understand owners' passionate commitment to historic cars. According to Dannefer the logic of the car enthusiast resembles Weber's notion of *wertrationalitat* (value-rationality). Hence, the car is no longer a way to achieve an end (e.g. getting from A to B) which would reflect the idea of *zweckrationalitat* (instrumental rationality), but has become an end, something to be valued in itself. In this respect, it is interesting to note that, while enthusiasts differ in their specific motivations of owning historic car(s), many owners prefer the car to be in original condition, or to be restored to its original specifications. It is this common goal that creates a sense of community (Dannefer, 1980).

That being said, the specific motivations to own a historic car may differ strongly and can even contradict. For example, some primarily own such vehicles to participate in shows and events. Such use of the car may conflict with the purpose of touring with the car, which generally negatively affects its presentation (Dannefer,1980). Still others mainly own these vehicles to restore them or to build up a collection.

Tam-Scott (2009) draws attention to the sustainability aspects of HV ownership. According to this author, the passionate commitment to a car means that owners tend to keep and maintain the car(s) for prolonged periods, which reduces negative environmental impacts. According to Tam-Scott (2009, p. 124)," the permanent and enduring relationship of classic car owners with their vehicle is an example of how should people redefine their consumption patterns when it comes to durable products such as cars."

Nieuwenhuis (2008) adopts a similar perspective. According to Nieuwenhuis (2008), the ownership/use of historic vehicles should be seen as a form of sustainable consumption. This means that consumers go beyond the intended lifetime of the products (such as cars) by consuming the products responsively, thus reversing unsustainable consumption behaviours.

Not only driving cars but also producing cars consumes energy. Based on literature Van Wee et al (2000) conclude that about 15 to 20% of the life-cycle energy requirement of new cars in the Netherlands (1990 – 1994) relates to car production, maintenance and disposal. Probably, production and disposal is by far the largest category within those 15-20 %. In the case of HVs, the additional (marginal) energy use for production and disposal approaches zero. On the other hand, HVs are less fuel efficient than modern cars. Regarding the CO_2 emissions of historic

vehicles compared to modern vehicles, based on data from the German car fleet between 1960 and 2011 as published in Knörr et al. (2012), Araghi & Van Wee (2015) conclude that during these years the CO_2 emissions have declined by 10%-20%. Therefore, they conclude that the additional energy use per kilometre due to the lower energy efficiency of HVs is in the same order of magnitude as the reduction in the energy use due to production and disposal. Note that the reduction of emissions of pollutants such as NO_x and PM_{10} are considerably larger, in order of 6 times and 2.5 times respectively (see: Araghi & Van Wee, 2015).

Finally, it has been argued that historic vehicles help to create "contextual ties" between people and their culture and social identity. The difference in technology and appearance of German, British or Italian historic vehicles are sometimes used to point out subtle differences between people of these nations and explain some social constructs of these societies; for example: German cars being "well-built" and "reliable" and Italian cars being "expressive" and "temperamental" (Tam-Scott, 2009, p.120-121).

To summarize, unlike the general literature on car ownership, which primarily focuses on the instrumental use of the car, the limited literature on HVs mainly focuses on social, cultural and sustainability aspects of HV ownership. According to Steg (2005) and Anable et al. (2005), non-instrumental and affective motivations play an important role in car use and ownership. However, with respect to historic cars, little empirical evidence is available related to these motivations. Based on the studies reported above, it can be expected that these non-instrumental motives even play a stronger role in HV ownership and use. The present study aims to fill this knowledge gap and explore motives that play a role in vehicle ownership and use across various types of historic car owners.

3. Methodology

Latent class cluster analysis is used in this study to explore heterogeneity among historic car owners. This explorative analysis will produce segments amongst owners with similar characteristics within each segment and varying characteristics between segments. These segments are determined quantitatively based on empirical evidence drawn from a survey among historic car owners. This classification will help us identify common characteristics among different owners in terms of vehicle use and ownership. It can reveal which motives are behind historic car use and whether owners in segments use their car differently in terms of mileage which is an important criterion from a policy perspective.

The main idea of latent class cluster analysis is that a discrete latent variable can account for the observed associations between a set of indicators, such that, conditional on the latent class variable, these associations become insignificant. This is generally called the assumption of local independence (Magidson and Vermunt, 2004). The goal is to find the most parsimonious model, i.e. with the smallest number of latent classes, which can adequately describe the associations between the indicators.

While cluster research in the transport domain often relies on the deterministic classification method of cluster analysis to identify homogeneous clusters, latent class cluster analysis is a model-based clustering technique which probabilistically assigns individuals to classes or clusters. This reduces misclassification biases. Additional benefits over deterministic cluster analysis are that (1) statistical criteria can be used to judge the optimal number of classes, (2) the significance of the model parameters can be computed and assessed and (3) variables of

mixed-scale type can be accommodated (hence, there is also no need to standardize variables) (Vermunt and Magidson, 2013).

Since this study is the first to identify latent clusters among historic car owners, there is no prior information on how many classes may exist or what these classes may represent. Hence, we conduct an exploratory latent class analysis where the number of latent classes is not known a priori. We use the Bayesian Information Criterion (BIC) to determine the optimal number of latent classes for our sample of respondents (Schwarz, 1978). This evaluation criterion weighs both model fit and model parsimony (the number of parameters) and has been shown to perform well in the context of mixture modelling by Nylund et al. (2007). When assessing latent class models with different segment numbers (but similar input variable), the model which has the lowest BIC value is the most prefered one, given that the segments found by the model have interpretable grounds.

The data for the model were provided by the Fédération Internationale des Véhicules Anciens (FIVA) and collected by GFK[4]. These data were collected in a cross-sectional survey conducted in April and May 2014. The objective of the survey was to obtain a general overview on HV enthusiasts and their level of activities and participations with the HV movement. The survey was distributed among FIVA's member organizations in 15 EU countries (Austria, Belgium, Czech Republic, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Poland, Spain, Sweden and the United Kingdom). These countries have active federations for HVs, resembling various historic vehicle clubs and communities. FIVA maintains regular contact with these federations in each of these countries and conducts surveys to obtain updated information on historic vehicle ownership, usage, and related activities. The questionnaires of the survey were either disseminated by GFK (on behalf of FIVA) among car owners in paper format, via clubs or via an internet-based link.

The survey contained questions on various issues, such as the number of vehicles owned, the number of kilometres driven in the previous calendar year, technical information about each vehicle, the number of accidents with historic vehicles, the amount of expenditure on vehicles, the membership to HV clubs and the participation in HV related events. The survey included all types of historic vehicles: passenger cars, motor cycles, mopeds and scooters, tractors, and commercial vehicles. However, for this study we only consider those respondents that owned at least one or more historic passenger car(s). This is done to reduce the complexity involved with the diversity in vehicle types and the fact that majority of the sample (83%) involved passenger cars owners (at least owning one passenger car).

For the LCA model in this study we selected five indicators: historic car ownership (out of 5 possible to report), mileage in kilometres per year, membership to clubs, the most important motivation behind historic car ownership and the participation in HV events. With some initial model runs, we concluded that these five measured variables summarize the main characteristics of the enthusiasts well. Four demographic characteristics were included in the model as predictors of class membership (so-called active covariates), namely age, the residential area, income and the employment status (Lanza and Rhoades, 2013).

Finally, one inactive covariate was considered as well, namely the expenditure on HVs. This variable was not included as a class indicator, because the reported expenditures related to all HVs and therefore may also relate to other historic vehicles (in addition to passenger cars).

[4] GFK is one of the leading institutes offering market research (see: http://www.gfk.com).

However, to still take this variable into account, it was included as an inactive covariate. This means that this variable is not part of the model, but that after estimation, the distribution of this variable is calculated for the various classes (using the model's posterior probabilities). (Vermunt and Magidson, 2002).

4. Results

4.1 Descriptive statistics

Altogether 19432 HV owners and enthusiasts successfully completed the survey throughout the 15 EU countries. From this, 16052 respondents, who owned at least one historic passenger car was selected. Note that these respondents may have owned other types of historic vehicles (e.g. motor cycles, trucks or even buses). However, they must have reported at least one passenger car. To keep the data set to a reasonable size, each respondent was allowed to register up to 5 vehicles in each category (i.e. 5 trucks, 5 buses etc.).

Table 1 shows the number of historic cars registered per person in the survey. In total the information of 30941 historic passenger cars were registered. On average, 1.93 cars were reported per owner with a variance of 1.4 cars and most owners indicated to have only one car (51.5%).

TABLE 1 Number of historic passenger cars registered per owner in the survey

No. of cars	Frequency	%
1	8268	51.5
2	3849	24.0
3	1842	11.5
4	1016	6.3
5	1077	6.7
Total	16052	100.0

Table 2 presents the response rate per country. Some countries such as France, Germany, Netherlands and Sweden were strongly present in the survey and some not. This could be partly routed to the population of those countries and partly to activeness of the historic vehicle federation and its level of contact with the owners.

Table 3 provides the socio-demographic distributions of the sample. The dominant presence of male respondents (97.5%) is striking. This finding is in line with previous studies (Dannefer, 1980; Delyser and Greenstein, 2015) and also the observations of FIVA's own previous survey, conducted in 2006 (Frost and Hart, 2006). Moreover, people from various age and income groups were present among the owners of historic vehicles. An exception, however, is group younger than 30 which has a very low share (3.7%). The 50 to 70 years old owners constitute the majority of the sample (57.9%). This group corresponds with the age of baby-boomers in the EU and US (1946-1964). This confirms the claims of Sass[5] (2014), who concludes that 58% of the 5 million classic car owners in US are in this age category and soon will be considering selling off their collection of classic cars due to retirement.

TABLE 2 Distribution of respondents per country

[5] http://www.caranddriver.com/features/baby-boomers-created-the-classic-car-marketand-could-crash-it-feature (accessed: Nov 2016)

Country	Participants	%
Austria	643	3.97
Belgium	1130	6.97
Czech	90	0.56
Denmark	919	5.67
France	3054	18.85
Germany	2435	15.03
Greece	355	2.19
Ireland	206	1.27
Italy	513	3.17
Luxembourg	140	0.86
Netherlands	2506	15.47
Poland	451	2.78
Spain	268	1.65
Sweden	2586	15.96
UK	905	5.59

TABLE 3 Distributions of socio-demographic variables

Variable	Categories	%
Gender	Male	97.5
	Female	2.5
Age	<30	3.7
	30-50	28.8
	50-70	57.9
	>70	9.6
Working status	Student-apprentice or intern	1.4
	Employed	49.2
	Owner or partner of a business	20.6
	Jobless (for whatever reason)	2.5
	Retired / pensioner	26.3
Gross annual family income (Euros per year)	<25,000	19.7
	25,000-45,000	18.5
	45,000-67,500	15.3
	>67,500	16.0
	Missing	30.5

4.2 The latent class model

To determine the optimal number of latent classes, we estimated a series of models with 2 to 9 classes. Table 4 presents the model fit statistics. In this table information about models with 4 up to 8 classes are shown. The BIC criterion value was lowest for the 7-class solution, indicating that this model was statistically optimal (Nylund et al., 2007).

TABLE 4 Model fit statistics

Number of classes	Log-likelihood	BIC	No. of parameters
5	-127839	256889	125
6	-127669	256800	151
7	**-127529**	**256773**	**177**
8	-127434	256833	203
9	-127322	256863	229

Table 5 presents the profiles of the seven latent classes. The top row in table 5 displays the class sizes. These seven classes are interpreted below.

TABLE 5 Latent class sizes and profiles

		Class 1 Recreational owners	Class 2 reserved owners	Class 3 Repair men	Class 4 Die-hard fans	Class 5 Next gen. HV fans	Class 6 Frequent drivers	Class 7 Collectors
Class Size (%)		0.28	0.21	0.15	0.13	0.09	0.08	0.05
Latent class indicators								
HV ownership (out of 5 possible to report)		1.63	1.42	2.15	2.97	1.87	1.68	2.80
HV use in kilometres (kilometre per year per HV)		2205.7	464.1	1057.4	3028.8	1865.5	5660.9	2551.2
Member of HV clubs (number)		1.45	0.97	1.86	2.30	0.91	0.80	1.58
The most important motivation behind HV ownership (%)	Doing maintenance, repairs, restoration jobs	0.00	0.22	0.44	0.18	0.40	0.19	0.13
	Recreational touring, taking part in events and shows	0.88	0.23	0.00	0.53	0.30	0.22	0.31
	Taking part in rallies or race events	0.06	0.01	0.03	0.12	0.02	0.01	0.16
	Use for daily transport	0.00	0.01	0.00	0.03	0.04	0.16	0.01
	Nostalgia	0.06	0.48	0.49	0.13	0.18	0.39	0.15
	Build-up of a collection	0.00	0.03	0.04	0.02	0.07	0.00	0.20
	Investment (expected value increase)	0.00	0.02	0.00	0.01	0.01	0.03	0.05
Participation in HV events in the last year (number)		4.93	1.27	4.65	6.53	4.15	1.70	3.76
Active covariates								
Year of birth (mean)		1957	1960	1955	1957	1974	1963	1960
Spatial area of living, number of inhabitants (%)	>500,000	0.13	0.16	0.10	0.12	0.11	0.19	0.21
	100,000 – 500,000	0.12	0.13	0.11	0.11	0.10	0.16	0.18
	50,000 - 100,000	0.09	0.09	0.10	0.08	0.08	0.10	0.07
	25,000 - 50,000	0.11	0.10	0.10	0.08	0.08	0.09	0.07
	10,000 - 25,000	0.15	0.12	0.11	0.12	0.13	0.12	0.06
	<10,000	0.21	0.18	0.18	0.24	0.24	0.16	0.19
	Rural area (outside built-up area)	0.19	0.21	0.29	0.25	0.25	0.17	0.24
Family income (in euros)		56198	57185	57429	62134	49800	57778	97814
Status in 2013 (%)	Student, apprentice or intern	0.00	0.01	0.00	0.01	0.08	0.02	0.00
	Employed by a company	0.39	0.35	0.36	0.28	0.62	0.37	0.08
	Employed as a civil servant	0.07	0.10	0.10	0.07	0.11	0.08	0.00
	Employed non-profit organization, in healthcare, education	0.03	0.03	0.02	0.02	0.01	0.07	0.01
	Employed by a type of organization, not mentioned earlier	0.02	0.02	0.02	0.01	0.02	0.02	0.01
	Owner or partner of a business, or other self-employed work	0.15	0.21	0.11	0.24	0.11	0.22	0.82
	Jobless (for whatever reason)	0.02	0.03	0.02	0.02	0.04	0.03	0.01
	Retired / pensioner	0.32	0.24	0.36	0.35	0.00	0.19	0.07
Inactive covariate								
Last year's expenditure per car (euro)		2231	1770	1862	2387	1939	2236	3148

Car owners assigned to the first class (28% of the sample) are identified as 'recreational owners'. Members of this class own 1.63 cars on average and drove 2205 kilometres with their historic cars in the last year. Around 88% of people in this class chose recreational touring and taking part in events as the main motivation behind owning historic car(s). On average the respondents in this class attended 4.9 HV related events. Roughly 55% of the respondents in this class live in rural areas or towns with less than 25,000 inhabitants. Dannefer (1980) gives a description of classic car enthusiasts that fits well with this class. According to Dannefer (1980) this group represents enthusiasts who may show their cars, but this has low priority.

Instead, touring is the preferred activity and those who have more than one car typically choose one car for showing and one for touring.

Members of the second class (21% of the sample) are termed 'reserved owners', because respondents in this group drive only 464 kilometres per year per historic car. People in this class own the least number of cars (1.42 on average) compared to the other classes. Members of this class also report the lowest participation in HV events (1.27) and lowest average spending related to their historic car (€ 1770 per car per year). Members of the class mainly seem motivated by nostalgic reasons to own a historic car, and therefore we conclude that this type of owners reserved their interests towards keeping the heritage and memories of historic vehicles alive and perhaps like to preserve HVs for future generations.

The respondents assigned to the third class (15% of the sample) are labelled as 'repair men', since they mention maintenance, repair and restoration as one of the main motivations behind their HV ownership. Dannefer (1980) acknowledges restoration of historic vehicles as a major activity of HV fans. While members of the third class enjoy HVs mainly for reasons of maintenance and restoration, they also mention nostalgia as a reason for their enthusiasm for historic cars. 58% of the respondents in this class live in towns under 25,000 inhabitants or in rural areas. Compared to the other classes relatively many people in this class are retired (36%).

Members of the fourth class (13% of the sample) are termed 'die-hard fans', because they own on average 2.97 cars and also drive second most (3,028 km per year). On average, they are member of 2.3 HV related clubs and have attended 6.53 events during the last year (both figures are highest across the clusters), which makes them the most active enthusiasts in the sample. Again, over one third of the members of this class are retired or pensioners, with an average annual income which is second highest compared to the other groups.

The members of the fifth class (9% of the sample) are labelled as the 'next generation of HV fans'. Respondents assigned to this cluster are the youngest with an average age of 32 (~15 years lower than the other clusters). Their income is also lowest of all. In addition, members of this class are more often students/interns or employed by a company as opposed to being unemployed or being retired. This group of owners drive each one of their cars 1865 km per year. Surprisingly, 62% of the members of this cluster live in rural areas or towns smaller than 25,000 inhabitants. The percentage of population living in the rural areas in Europe in this age range (around 40 years old) is about 23% (de Beer et al., 2014), which is not consistent with our observation. A potential explanation could be the availability of space to stall historic cars in the rural areas giving rise to large number of owners being present in rural areas.

The members of the sixth class (8% of the sample) are identified as 'frequent drivers'. This label relates to the fact that they have driven the most in the past year (5,461 kilometres). More than one third of the respondents in this class live in towns with 100,000 inhabitants or more. Around 16% specifically mentioned daily transport as the main motivation behind owning a historic car, which is the highest compared to the other classes, but still relatively low. The members of this class report the lowest (average) membership of HV clubs (0.8).

Finally, respondents assigned to the seventh class (5% of the sample) are identified as 'collectors', since respondents in this class own on average 2.8 cars. 20% of members of this class mention the build-up of a collection as the main motivation for owning a historic car and another 5% regard their HV as an investment, expecting an increase in value over time. This class represents the smallest group in the sample including only 5% of the respondents. In line

with the collector profile, the annual income of the members of this class is the highest compared to the other classes. Dannefer (1980) mentions collecting (historic cars or related objects) as one of the important activities of enthusiasts but also acknowledges that not a lot of them have the financial means of building a collection. For this subgroup of enthusiast 'locating and acquiring the object' is the most enjoyable part of being a collector (Dannefer ,1980 , p. 402). Tam-Scott (2009) also recognizes the existence of this subgroup among the HV enthusiasts.

Looking at the expenditures (as presented in the last row of table 5), the 'die-hard fans' and the 'collectors' have spent the highest on their cars. This may be a reflection of their level of activity and commitment to the HV movement. Members of the second class, the 'reserved owners', spend the least, which stems from their low level of activity (i.e. participation in events and gatherings) and low mileages which means less expenditure on fuel, maintenance and spare parts. The third class 'repair men' spend second least on their historic cars. It may be speculated that people in this class attempt to repair and restore the vehicles themselves and thus spend less for restoration and maintenance services. 'Frequent drivers' also spend a relatively high amount, which is in line with their heavy use of their car(s).

Regarding the living area of the historic car owner, the majority (67%) lives in small towns and rural areas (i.e. less than 50,000 residents), though this figure is less for the 'frequent driver' (54%) and the 'collector' groups (56%). Given the residential locations of enthusiasts, these vehicles are mainly driven outside congested and polluted areas.

5. Discussion and conclusion

This study has revealed seven distinguishable classes of historic passenger car owners, using data from a large survey among HV owners. The results indicate there is large heterogeneity in the ownership and use of historic cars and the reasons behind ownership. Some enthusiasts seldom drive their cars, whereas others drive quite a lot. Some car owners very actively participate in HV related clubs and attend events whereas others enjoy repairing and maintaining their historic cars. These findings may be of interest for historic car organizations such as FIVA or for HV clubs, which may want to know what the main motivations of their members are by HV ownership and use. Subsequently, customized events and shows or workshops can be organized targeting different sub-groups of HV enthusiast. The companies which provide technical support (maintenance, repairs, and restauration) and spare parts for enthusiasts may be willing to know what the level of ownership, annual mileage and also the amount of expenditure by these groups of owners is.

Looking at the results, in general, one can observe that historic car owners drive much less than modern car owners. On average, owners in our sample drove a distance of 2404 kilometres in the year prior to the survey. Among the seven classes of owners, the highest mileage per car was measured in class 6 "frequent drivers", who drove on average 5660 km per car per year. This class only constitutes 8% of the respondent in the sample. The global average distance travelled with a passenger car per year is estimated to be around 13000 kilometres (Holmberg et al., 2012). This is 5.4 times more than the average distance travelled for the overall sample of owners and also 2.3 times higher than members of "frequent drivers" class.

Looking at the affective reasons of owning historic cars, we observed that recreation and showing off the car(s) at events was strongly indicated by at least two segments of owners (class 1 and class 4). This could be loosely compared with the feeling of "arousal" and "superiority"

defined by Steg (2005). Owners in class 7 referred to "building up of a collection" as the second most important aspect of historic car ownership (and the highest among all other segment). This could also refer to the feeling of status and superiority. Alternatively, three segments namely class 2, 3 and 6 indicated "nostalgia" as the main reason of owning historic vehicles, which can be related to emotional reasons of vintage car ownership. Schwanen and Lucas (2011) found emotional motivations among the non-instrumental reasons of (modern) car use.

From a policy perspective, the environmental impacts of the historic vehicles play a major role in regulations regarding historic cars. Although historic car owners drive much less than average modern car owners (according to our sample), the pollution emitted per kilometre by historic cars is much higher. At this point, the outcomes of this study can provide some insights for policy makers.

Our study reveals that there are significant differences in annual mileage between various types of owners. If we assume emissions to be proportional to the distance travelled, then from the 7 types of owners, the frequent drivers (class 6) could be the most important target group for environmental policies, given that the owners in this segment drive 2.3 times more than the average mileages of the entire sample.

To reduce the environmental impact of HVs we believe a system of 'charging per kilometre' would be an elegant option. Such a system will be a disincentive for frequent users, which is not only good for the environment, but also for the preservation of HVs. And it avoids infrequent users to suffer from generic policies such as the introduction of environmental zones, forbidding all older vehicles to drive in that zone.

An alternative could be 'charging based on a quota'. This quota can be based on the emission levels of each historic vehicle. This is not difficult to estimate for historic vehicles, given the type, the year of manufacturing and some technical details. Based on such a policy, each historic car receives a limited number of kilometres per year as a quota. If the owner drives within this quota, there will be no penalties. If the driver exceeds this quota, then there could be a sort of environmental tax levied on the owner, which varies based on the emission levels of the vehicle. The basis of this quota system can be based on two items: a) technical features of the vehicle and b) the average distances driven by the majority of the historic car owners (for instance in our sample 73% of the car owners drive less than 2205 kilometres per year).

We made a rough calculation on the magnitude of the impact of this policy on CO_2 emissions. Assuming that there are approximately 2 million HVs in the EU (Frost et al., 2006), and that about 80% (1.6 million) of these are historic passenger cars, and that 8% of these HVs is used frequently by class 6 type owners ("Frequent drivers") as estimated in our LCA analysis (see table 6), then the "charging based on quota" will force these drivers to either drive under the 2200 km/year limit or pay the penalties. If these drivers choose to stay under the 2200 km/year borderline, this reduces the kilometres driven by 443 million km/year. An average car (e.g. Ford Focus made in the year 2006) emits 170 gr CO_2/km (based on UK department of transport emission calculator[6]). According to Knörr et al. (2012) an average historic car manufactured after 1960s emits 20% more CO_2 emissions (205 gr CO_2/km). In total the 443 million km/year driven less by historic passenger cars would be equivalent to roughly 91,000 tons of CO_2 emission reduction in the EU. This is corresponding to the emissions of approximately 54,000 new cars driving 14,000 km/year, or equivalent to the to the total CO_2 emission of cars of a

[6] http://carfueldata.dft.gov.uk/ (accessed: Nov 2016)

medium sized city with 110,000 inhabitants in EU (based on average car ownership figures of Eurostat[7] of 490 cars per 1000 inhabitants in EU). It may not seem a drastic reduction in total emissions of road vehicles in the EU, however, given the limited mileage of HVs in general, this could be a significant reduction on the use of HVs by the frequent users.

In general, an important challenge for policy makers is to find the right balance between restricting the use of HVs for environmental reasons and, on the other hand, not imposing too many restriction on users that hardly cause any emissions due to their very limited mileages. As a finale note, since this is one of the first academic studies in the field, there is a need for more research to be conducted related to this growing category of road transport. Besides concerns about air pollution, there is the issue of safety and also noise which requires more in-depth analysis in the case of historic vehicles.

A limitation of the present study is that the sample for this survey was gathered from HV enthusiasts who were either members of HV clubs or were in contact with the historic vehicle movement. As a result, we cannot claim that this sample is representative for all HV owners. It is likely that people who use their historic car solely for daily transport are underrepresented.

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