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# OLD VEHICLES UNDER NEW GLANCE: A LITERATURE REVIEW AND ADVANCED DATA ANALYSIS ON HISTORIC VEHICLES


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# Executive Summary

This report is composed of two parts: a literature review on published material relating to historic vehicles and a data analysis on the survey gathered from historic vehicle owners in 15 EU countries.

The literature review, which is a first of its kind in the field of historic vehicles (HVs), objectively looks at published academic material, reliable books, research reports and databases. Since there were limited academic works to refer to, we also considered some non-academic material (grey literature) and opinions of experts.

It was found that the number of vehicles over 30 years old is growing with a share of 1% of vehicle fleets across the EU, although with varying percentages among different countries (as high as 7% or as low as 0.5%). 90% of HVs are either passenger cars or motorbikes, and their yearly mileage share is reported to be between 0.25% and 1.5% of all cars. Furthermore, the material on HV related emissions, safety, environmental impacts, social and economic benefits were reviewed.

The second part, advanced data analysis, takes an in-depth look at the gathered data from HV owners. We observed various characterises of owners such as: country, income, living area, club membership, age of owners (among others) and investigated their relationship on important criterions on HVs such as ownership, usage and expenditure.

We saw that respondents from central European (e.g. Germany, Luxemburg, Austria) countries spend most on their HVs and also drive most. Respondents in Southern and Eastern European countries spend the least but drive about as much as average.

We found out that the usage and expenditure of owners substantially differ among different income groups but not when it comes to ownership. On average high income earners spent 4 times more on their total HVs than the lowest income people. Both very low income and very high income drive HVs more than average (13% and 29% respectively). Low income owners probably used HVs as a means of transport and high income people had multiple HVs and in total they drove more on their HVs than average.

HV ownership in congested areas was 30% lower than in the quiet and uncongested rural areas. However, the use of HVs and expenditure on HVs do not significantly differ between various spatial living areas.

Middle-aged owners (between 53 to 70 years old) spend the most on their HVs with annual spending of more than 8500 euros in total. Whereas the youngest group of enthusiasts spend altogether around 4300 and the oldest group of owners spend no more than 3000 euros on their HVs.

From our analysis we found out that mid-60s to mid-70s were the golden ages of old-timers with the highest number of HVs in the data set. Moreover, 60% of HVs were driven less than 2500 km in line with previous findings.

Using latent class analysis, we determined five clusters of HV enthusiast and revealed some common behaviours and characteristics in each of these clusters. Finally by using SEM, we showed how activeness of HV enthusiasts and the quality of vehicle maintenance can be measured via relevant parameters in the data set. We determined how these concepts influence the condition of HVs.

# General Introduction

This report has been compiled to present the research findings of Delft University of Technology regarding historic vehicles (HVs). This research was commission by Fédération Internationale des Véhicules Anciens (FIVA) to conduct two studies:

a) A literature review on articles written about historic vehicles in the public media and also in academic publications.
b) Advanced data analysis on the survey that was completed by HV enthusiasts in 15 EU countries in 2014.

The report is, therefore, composed of two parts: Part 1 deals with the literature review and part 2 delivers the data analysis.

In part one we look at the available published material to date on HVs, focusing on central issues such as: usage and ownership of HVs, environmental impact of HVs (emissions and noise), safety considerations, social and economic impacts of HVs. We also investigated the share of HVs in vehicle fleets in different EU countries. Although there is a lack of reliable material on HVs, we have tried to gather and cross check the information from different sources and hence verify the material in this manner.

In part two we used the data set that was obtained from more than 19 thousand HV enthusiasts and conducted several data analysis methods to reveal as much information as possible in the dataset. We focused on three central criterions: ownership, expenditure and usage of HVs and investigated the impact of important factors on these criterions. Some of these factors are listed as: age, income, living area of owners, and membership to HV clubs.

We checked how safely the HV enthusiasts drive based on their reported incidents in year 2013. We also looked at fuels available in the market and the possibility of use for HVs.

Regarding the expenditure on HVs, we investigated the relationship between age of the vehicles and different categories of costs such as restoration and maintenance costs and also running costs such as insurance and road tax.

We identified different latent clusters among HV enthusiasts. These clusters are formed based on the answers of respondents to survey questions. The advantage of clusters is that they reveal different types of HV owners and distinguish preferences and behavioural aspects among the clusters. These aspects provide underlying information from the data that are not readily observable.

Finally we developed latent constructs which explain some broad concepts with the observed data. We determine how activeness of HV enthusiast and quality of their maintenance can impact the vehicle conditions. We also show how these concepts can explain the answers of enthusiast to the questions in the survey.

We also provide a rough estimate of the number of people employed in jobs servicing the HV movement.

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# Part 1: A review of literature related to historic vehicles

## 1. Introduction

This part gives an overview of literature on historic vehicles. Before presenting the rationale of this part we first pay attention to what a historic vehicle is. According to the definition provided by Fédération Internationale des Véhicules Anciens (FIVA), historic vehicles (HVs)[1] are those means of transport, whether two wheeled or more, that have more than 30 years of age from their inception (FIVA, 2014b; Frost & Hart, 2006). This specific category of transport, either on-roads or in preserved conditions (off-road), requires special attention due to its age and the heritage it is bearing to inspire future generations. In 2009, European Parliament officially endorsed a vehicle of "historic interest" if it fulfils the following conditions (Directive 2009/40/EC):

- It was manufactured at least 30 years ago
- It is maintained by use of replacement parts which reproduce the historic components of the vehicle
- It has not sustained any change in the technical characteristics of its main components such as engine, brakes, steering or suspension and
- It has not been changed in its appearance.

However, in 2014, EU parliament modified its previous directive and recognised vehicles with following characteristics, as "vehicles of historic interest". For comparison purposes, we report the current EU definitions in here (DIRECTIVE 2014/45/EU - page 57):

" - It was manufactured *or registered for the first time* at least 30 years ago;

- Its specific type, as defined in the relevant Union or national law, is no longer in - production;
- It is historically preserved and maintained in its original state and has not undergone substantial changes in the technical characteristics of its main components."

According to above definitions not all vehicles over 30 years are historic vehicles. In practice, it is rather challenging to distinguish historic vehicles from other vehicles with 30+ years that are modified or have been manipulated and do not preserve their original state.

For practical reasons we assume that historic vehicles discussed in this report are 30+ years old (for young-timers[2] the assumed age is 25 to 30 years). However, not all 30+ vehicles are considered to be HVs (e.g. according to the definition of FIVA or the EU). Some literature that we have considered in this study only consider vehicle age (e.g. 25+ or 30+ year old vehicles). All vehicles of, for example, over 30 year old might not be representative of HVs only, e.g. because HVs might be driven less or more carefully, and might be more valuable than average). We could not correct for this. We now discuss changes in the number of HVs. An important factor leading to availability of historic vehicles,

[1] Throughout this report we abbreviate historic vehicles as HVs and historic vehicle as HV.
[2] Young-timers will be explained in section 3.

in current days, is the number of cars manufactured prior to three decades ago. Based on figures form the Worldwatch Institute, the worldwide auto (cars) production rate started to grow gradually since early 50s (estimated to be 8 million auto productions annually) and this pace became more rapid in 60s (reached around 20 million by mid 60s) and 70s when the annual auto production reached to 31 million in 1979 (Renner, 2003). With more autos being produced, there are potentially more vehicles that can survive and become HVs. In addition, the life expectancy of vehicles is increasing. According to statistics from the USA, in the 90s the average survival rate for cars above 30 years was 6.6% (trucks 45.1 %) whereas this figure in 80s was 0.8% and in 70 was 0.4% for cars and 20.7% for trucks (Davis, Diegel, & Boundy, 2014). Thus the numbers of vehicles over 30 years are steadily increasing and this means that potentially the numbers of HVs have been growing. On the other hand, one might argue that because modern vehicles are more complex and therefore maybe less easy to repair and restore once they are 30+, fewer of these vehicles might be preserved as HVs.

If the number of HVs grow, then the number of enthusiasts and maybe also the number of HV clubs might increase and HVs may gain more popularity and attention among the public. This could lead to an increase in their importance from a policy making point of view.

Nevertheless, policy makers face an initial dilemma when focusing on the issue of historic vehicles. On the one hand, HVs get more popularity from the perspective of the owners and maybe also other people who enjoy them, and consequently HVs became relevant from economic point of view. But on the other hand HVs probably become an issue from environmental and maybe safety point of view, since more recently manufactured vehicles are cleaner and safer (mainly due to regulations and improvements made by vehicle manufacturers). In some countries, policy makers have taken measures to restrict the use of old vehicles and encouraged scrapping them (see Van Wee, De Jong, and Nijland (2011), for an overview of literature), while in others (e.g. Sweden and UK) car owners were motivated to increase the lifespan of vehicle (Nieuwenhuis, 2008). Note that the measures do not distinguish between HV (e.g. based on the EU or FIVA definitions) only or 30+ years old vehicles. In other words, the measures relate to all categories of vehicles based on age, ignoring conditions or the distinction between HVs and 30+ years old vehicles.

Despite the above mentioned claims and counterclaims on existence of HVs, to the best of our knowledge, there is hardly any academic and independent research being published with respect to HVs and relevant policy measures. The lack of academic research in this field reflects the significance and relevance of this study. Indeed, policy making requires input in the form of facts and figures to be able to find out if policies are needed anyway, and which policy options makes sense, and have a high benefit to cost ratio to the society.

This part of the report aims to give an overview of literature and available data with respect to HVs. For the sake of giving structure to this report and to keep consistency with articles published in the transport policy domain, we focus on the four main topics on which transport policy focuses: 1) environmental issues, 2) safety related issues, 3) congestion, and 4) impacts on the economy and wider society. Moreover, in this part we will seek to find research gaps and challenges in HV related topics.

Due to the lack of academic literature we were forced to use some grey literature and databases that was partly retrieved by us and partly provided by FIVA. Some of the material used for this report has not been published in peer reviewed academic journals or in any other academic form. However, some reports have been written by university staff thus one can assume that these reports have been written with scientific impartiality (i.e. with a relatively high level of independency).

In this report we introduce our methodology in section 2, where we explain how this review is conducted. Then, in section 3, we delineate some terms and definitions that are widely used in HV literature. Next, in section 4 through 6, we explain about our findings about HV ownership, HV usage and Environmental impact of HVs. We talk about safety considerations in section 7 and the impact of HVs on the issue of congestion in section 8. Finally in section 9, we explain about positive effects of HVs. We conclude the report in section 10 by summarizing the findings and discuss some topics for future research in this field.

## 2. Methodology

We used the well-known academic data bases such as SCOPUS, Web Of Science (WOS), and Google Scholar as our search engines. However, in many cases when we entered keywords such as: "historic", "classic" , "Vintage" combined with "vehicle" or "car" as our search words, hardly any relevant results were returned, clearly indicating the lack of published material in this field.

For this literature review on HVs, we would have preferred to primarily use articles published in peer reviewed academic journals. However, because these hardly exist, we were forced to use grey literature and databases, some provided by FIVA. We included only those sources that had traceable underpinnings or were published by research institutes. This means documents without references or a description of the methodology of how content was derived, were excluded, as well as documents published by an interest group. In practice both criteria were highly correlated: documents without underpinnings were often published by interest groups.

Thirdly we used some sources that did not appear in academic journal but are highly recognised in the field of transport such as: the Transportation energy data book edition 33 by Davis et al. (2014), which is published annually in the United States since 1981, or data bases from Eurostat regularly published by European Commision. Fourthly we use our own calculations, estimation or inferences that were derived from cross checking different reports, tables and graphs in non-academic materials (grey literature). Finally we used own experience[3] and conclusions from discussions with experts in the field of historic vehicles (several discussions with FIVA members and other HV experts). Below we will make explicit references to sources that are used in this report.

## 3. Terms & Definition

Historic vehicles, regardless of their type and condition, are divided into two main categories, namely: old-timers and young-timers. There are slight disagreements between different reports on the minimum age at which a vehicle should be called a young or old-timer. Some document refer to vehicles older than 30 years being old-timer (Frost, Hart, & Kaminski, 2011), but some official agencies such as Dutch bureau of statistics (CBS) counts vehicles more than 25 years as old-timers (Rijkeboer, 2008; Hoen et al., 2012).

[3] The second author of this report has three historic cars, and is a member of vintage air-cooled VW club Holland since 1983.

As for young timers, FIVA considers vehicles between 25-30 years old as young-timers (FIVA, 2014a). A study conducted by Verband der Automobilindustrie (VDA), Institut für Demoskopie Allensbach (IfDA) and BBE Automotive GmbH (BBE) regarding classic cars in Germany in 2013, refers to young-timers as vehicles between 15 to 29 years old.

There is another general categorization of HVs which refer to roadworthiness. If a historic vehicle complies with technical standards for public road use, then it is counted as roadworthy, otherwise the vehicle is non-roadworthy and is not allowed to appear on public roads as a mode of transport.

Finally, historic vehicles are divided into different types of vehicle in terms of their original purpose of use. FIVA identifies different types of vehicles into 11 categories: 1) Passenger car (incl. mini bus), 2) Racing car for circuit racing only , 3) Motorcycle, 4) Moped , 5) Scooter , 6) Camper van , 7) Commercial vehicle under 3500 kg GW (incl. vans, ambulances, hearses) , 8) Commercial vehicle over 3500 kg GW, 9) Military vehicle (all weight categories) , 10) Bus (other than mini-bus), 11) Tractor. Country statistics more or less follow these categories, although definitions are not exactly the same throughout the EU and outside the EU.

## 4. HV numbers and vehicle types

According to FIVA's census in 2006, there were 1,950,000 HVs in the EU from which almost 80% were roadworthy. The total fleet of vehicles in EU in 2006 was 255 million which means that HVs constituted less than 1% of the total fleet of vehicles in 2006 (Frost & Hart, 2006; Nieuwenhuis, 2008). From more recent sources available to us, we were able to establish a limited inventory of the overall number of registered historic vehicles and the total number of entire vehicle fleet (modern or old) in a few European countries. Table 1 shows HV ownership data (absolute numbers and shares in the fleets) for some EU countries.

**Table 1 Total HV and overall fleet sizes in some EU countries (all data are on all vehicle categories)**

| Country | Year | No of HV ( >30 years) | Total vehicle fleet | HV % to total fleet of vehicles | Source |
|---|---|---|---|---|---|
| UK | 2010 | 805,588 | 35.5 million | 2.27% | Driver and Vehicle Licensing Agency (DVLA) |
| Germany | 2013 | 313,815 | 53.0 million | 0.59%** | Kraftfahrt-Bundesamt (KBA)- Federal Motor Transport Authority (KBA) |
| Denmark* | 2012 | 79,055 | 2.20 million | 3.59% | Centralregisteret for motorkøretøjer (CRM) |
| Netherlands | 2000 | 121,000 | 6.3 million | 1.92% | Centraal Bureau voor de Statistiek (CBS) |
| Greece | 2012 | 402,932 | 6.75 million | 5.97% | Car Importers Association Representatives (CIAR) |
| Sweden* | 2013 | 213,363 | 5.37 million | 3.97% | Motorhistoriska Riksförbundet (MHRF) |

* Tractors have been excluded from the total vehicle figures. For further explanation see section 4.1.

** This figure is for registered vehicles older than 30 years. The percentage of all historic vehicle (registered and unregistered) adds up to 0.97% of all vehicle fleet.

Table 1 indicates HVs percentage of the total fleet of vehicles in some member countries. However, one should treat these data cautiously, since there are cases that vehicle owners do not necessarily de-register their vehicle when the vehicle is scrapped. Moreover, statistics are not based on a single standard so it is difficult to compare the aggregate numbers across countries. Statistics may or may not include some categories of vehicles and some may include only roadworthy and others may also include non-roadworthy vehicles. Therefore, the numbers reported on table 1 provide a rough estimate of HVs.

An interesting observation from table 1 is that the share of HVs in the total fleets strongly differs between countries, ranging from below 0.6% in Germany to almost 6% in Greece. However, it is important to realize that the quality of statistics varies. Partly based on information received from members of the HV community, we conclude that table 1 at least in some cases presents unrealistic figures. The figures for the UK, Denmark, and Germany probably reflect more reliable estimates of shares of HVs in vehicle fleets, than those of other countries because the sources of our data are from official institutions responsible for vehicle registration and are regularly published.

## 4.1. Breakdown HVs by type

The numbers of HVs can be broken-down by vehicle type. We found some sources providing relevant information. In the UK, in year 2011, around 90 % of HVs were passenger cars and motorbikes and 5% buses, coaches and trucks, 2% military vehicles and the rest were agricultural and steam vehicles (Frost et al., 2011). Similarly, we received another data set from German Association of the Automotive Industry (Verband der Automobilindustrie [VDA]) about the segmentation of HVs. In Germany, by end of year 2013, around 92% of HVs were cars, 2.5% motorbikes, less than 0.1% buses, 3% Trucks and 2.1% tractors. More recently, in a socio-economic survey conducted from 168,991 HV owners in France, in 2014, similar percentages of ownership have been reported by French historic vehicle association (FFVE). In the mentioned survey, 90% of HVs were passenger cars and motor cycles (55% and 35% respectively), 6.5% were busses and trucks and 3.5% agricultural and other sort of vehicles.

For two Scandinavian countries, Sweden and Denmark, we have received rather extraordinary data for 2013 and 2012 respectively by HV experts of those countries. Table 2 shows some key results. According to this table a very large number of Tractors are registered in both countries[4] (Sweden 47% and Denmark 22%) and similarly a large number of trucks have been registered in Sweden (5%). These percentages are much higher than reported in other studies which normally indicate that cars and motorbikes constitute around 90% of HV fleet.

**Table 2 Historic Vehicle breakdown in different countries**

| Category of Vehicle | Sweden (2013) | Denmark (2012) |
|---|---|---|
| Cars | 138,971 | 38,376 |
| Motorcycles | 53,389 | 37,611 |
| Buses | 134 | 1720 (vans) |
| Trucks | 20,869 | 338 |
| Tractors | 191,308 | 21,775 |

[4] One possible explanation for large tractor numbers, based on expert's opinions, is that these tractors are extremely durable and very sturdy manufactured. Farmers keep them as reserve tractors with light duties and when they finally do wear out they are just parked without any attempt to de-register them. Thus they remain registered.

## 4.2. Breakdown HVs by vehicle age

Alternatively, HVs can be broken-down by their age. A 2006 FIVA survey reported that 30% of HVs in EU member states were pre 1940, 30% were built between 1940 and 1960 and the rest (40%) were built between 1960 and 1975. One should note that 1975 was the most recent year for a vehicle to be considered a HV in that study.

Another interesting decomposition of HVs based on age is supplied to us by German Association of the Automotive Industry (VDA). VDA keeps a more accurate record of HVs by their age classes. Table 3 shows the breakdown structure of HVs in Germany, by end of 2013.

**Table 3 Historic Vehicle categorization in Germany by age (Source: VDA, 2013)**

| Age class in years | Percentage of total HVs |
|---|---|
| 30 - 34 | 19.6 % |
| 35 - 39 | 19.8 % |
| 40 - 44 | 24.8 % |
| 45 - 49 | 16.0 % |
| 50 - 59 | 14.5 % |
| 60 and more | 5.3 % |

One can see that the VDA data is not quite compatible with FIVA (2006) data. Vehicles aged between 1940 and 60s in Germany are more than 55%, whereas in FIVA data, it is said to be 30% and after 60s in FIVA data is much higher 40% compared with only 5% in VDA data.

# 5. HV usage

The second topic we discuss is the use of HVs, both yearly use of HVs as well as the share of historic vehicles in total road transport. Use (yearly mileage) of HVs is of paramount importance because it is showing the potential impact of HVs to the environment, safety and congestion. In addition to these policy relevant issues, HVs’ usage is relevant for HV related businesses (e.g. mileage is often used to calculate the premium amounts by insurance companies, and also by those institutions which deal with maintenance of HVs).

HV usage (or mileage) basically refers to how many kilometres (miles) historic vehicles were driven in a given length of time (generally: one year).

## 5.1. Average Kilometres driven by HVs (mileage)

The average mileage of HVs can be calculated under two scenarios: 1) for active vehicles only, 2) for all HVs, including non-active and preserved vehicles. In each of these scenarios different average mileages are derived. For instance in the case of Netherlands in 2006, average yearly mileage was 1950 km for active HVs (scenario1), and 1050 km for all HVs, active and non-active (scenario 2).

In year 2006, FIVA estimated that average annual mileage for HVs was 2100 km per year for scenario 1 (active fleet) and 1200 km for scenario 2 (active and non-active fleet). Furthermore, FIVA data showed that around 50% of HVs were used for less than 500 km per year and only 7% were used more than 3500 km per year (Rijkeboer, 2008). A UK study (Frost et al., 2011) has reported comparable figures and revealed that in 2011 more than 50% of HVs travelled less than 500 miles (800 km) per year and 18% of HVs were used weekly or more often. A recent survey, conducted by Dutch historic vehicle association (FEHAC) in 2012 showed that 45% of HVs are used less than 500 km per year (FEHAC, 2012), confirming the results of previous numbers announced in UK and FIVA reports. Meanwhile, the FEHAC study in 2012 also revealed that average mileage per HV decreased from 1950 km/year in 2006 to 1700 km/year in 2012 (overall reduction of 13%).

## 5.2. The share of HVs in vehicle use

This part of our review is mainly based on data for passenger cars. Very scars data sources were available for mileages of historic trucks, buses, or motorbikes. However, historic passenger cars constitute a big portion of HVs and they are more frequently used than any other type of historic vehicles.

In order to compare the use of HVs with fleet averages, we compare the total yearly mileage travelled by HVs with overall vehicle fleet statistics. In 2010, DVLA reported that the total vehicle circulation in the UK was around 308 billion miles (493 billion km) and the figure for HVs stood at 750 million miles (1200 million km) in that year, which makes 0.24% of total distance travelled by vehicles on UK roads (Frost et al., 2011). The same comparison can also be done at the EU level. In year 2006, the total distance travelled by modern vehicles equalled to 2.2 trillion km. HVs travelled 1.4 billion km which makes 0.06 % of distance travelled by the total fleet (Frost & Hart, 2006).

Hoen et al. (2012) reported somewhat different figures for year 2011, for the Netherlands. They conclude that cars manufactured in 1986 or before had a share of 1.5% in total kilometres of all cars in the Netherlands. Note that this number includes also cars of 25-30 years old. One possible explanation for this high percentage (i.e. 1.5%) is that in the years preceding 2011 many cars older than 25 years were imported to the Netherlands, at least partly because of tax exemptions (Hoen et al., 2012). However, this trend has been reversed due to new tax rules in the Netherlands and as a result many cars above 25 years are now being exported (Stolk, 2014).

The fact that HVs are used less than the (fleet) average can also be seen in figure 1, which shows the relationship between the age of a vehicle and annual distance driven in the Netherlands (Rijkeboer, 2008). Yearly use drops from 25,000 km/year for vehicles up to one year old, to below 5000 km/year for vehicles of 22 years old. At this stage the slope of the trend line becomes less steep, showing that vehicle use per year becomes almost constant. Those vehicles, which are not dismantled after the first 25 years of age, are normally owned by enthusiasts and are kept in good conditions. These vehicles are driven less than 4500 km per year (Rijkeboer, 2008).

Data from the most recent Transportation Energy Data Book - edition 33 (Davis et al., 2014) show that in 2014 in the USA, 73% of cars in their first years are driven more than 10,000 miles/year (16,000 km/year) whereas 60% of all cars over 20 years old are driven less than 6000 miles/year (9600 km/year). 30% of these 20+ years old cars are driven less than 2000 miles/year (3200 km/year). Note that the data book reports data for all cars over 20 years together, no disaggregation by age class for this data is provided. Nevertheless these data show the same trend of a decrease of use with age, as in the Netherlands.

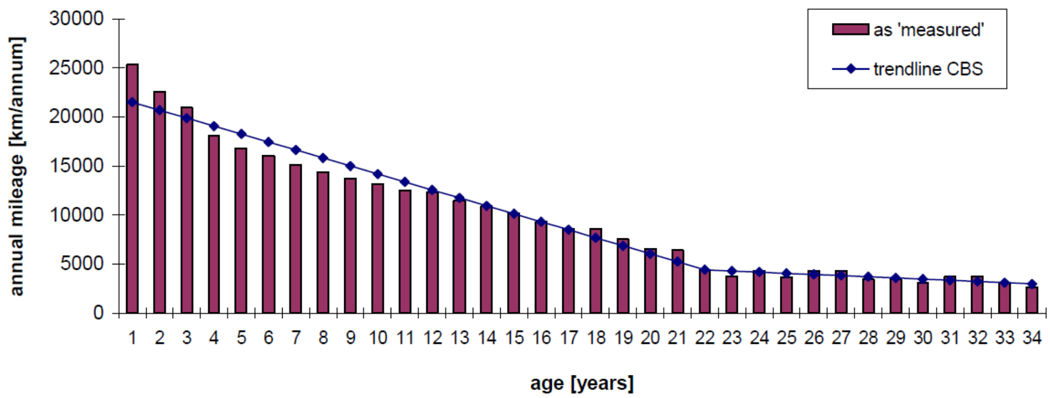


Figure 1 Annual vehicle usage in comparison to vehicle age, Source: Rijkeboer (2008)

Another relationship between age of cars and average annual kilometres driven was found in a study conducted by the German Institut für Energie und Umweltforschung (IFEU). In their first year, cars on average were driven over 20,000 km per year, whereas cars of 30 years were used less than 6,000 km per year (IFEU, 2012). The study does not provide data for vehicles over 30 years.

Annual use also differs within the group of cars above 30 years. A study of PBL (Hoen et al., 2012) found that in 2011 cars manufactured in 1970 were driven around 2000 – 2200 km/year, whereas those in the early 1980 were driven over 4000 km/year.

Putting all figures and estimates from different studies together one can conclude that yearly usage of HVs is far less than cars younger than 20 years old. The highest reported estimates for HV mileages do not go further than 6000 km per year.

# 6. Environmental impacts of HVs

Every transport mode has some environmental impacts which mainly concern the emission of various air pollutants, $CO_2$ emissions and noise. HVs being part of road transport with old engine technology are often challenged by authorities as being more polluting the environment than modern vehicles. In this section we will review what has been investigated, discussed or reported on environmental impacts of HVs in the literature.

## 6.1. Vehicle Emissions

Vehicle emissions are an important topic for society. Policy makers have responded by implementing rules and regulation. This has forced vehicle manufacturers to introduce new innovations in engine and exhaust technologies in order to produce cleaner, quieter and more fuel efficient vehicles over the course of years. However, HVs were produced long ago, they were subject to less stringent or even no environmentally relevant regulations. Consequently these have old engineering technologies. They often produce higher per kilometre emissions than modern vehicles do. On the other hand, the driving behaviour of HV enthusiast might compensate some of the differences in per kilometre emissions. We did not find any document or literature on driving behaviour of HV enthusiasts. However, assuming that enthusiast drive HVs relatively carefully and with low speeds, this might result in lower emissions than the fleet average. There are studies such as Kean, Harley, and Kendall (2003) which confirm that lower vehicle speeds would result in lower emissions.

In this study we focus on the share of only passenger cars (among all HV categories) in total emissions. The reason is that this category constitutes the majority of existing HVs and also the available studies regarding emissions of older vehicles have mainly looked at passenger cars only.

### 6.1.1. Non-$CO_2$ Emissions

At the European level, we did not find any information on the share of HVs in total vehicle emissions. However, Rijkeboer (2008) investigated several scenarios for the Netherlands regarding the use of vehicles above 25 years old. In the mentioned study he developed an emission calculation model called Analytical Model Old-vehicle Emissions for Burden Assessment (AMOEBA), specifically looking at CO, HC[5], $NO_x$, and PM as emission factors, and calculated the overall emission of 25+ year old cars in different scenarios. The model distributes kilometres driven over age classes, based on data of Dutch bureau of statistics (CBS), and has age class specific emission factors. Figure 2 shows the share of 25+ cars in total emissions, which is obtained from Rijkeboer (2008) study. Even in the "worst case scenario" the share in emissions of $NO_2$ and PM would be below 2%. With an estimated share of 15%, for 2015, HC was the pollutant with the highest share for 25+ cars (Rijkeboer, 2008). Note that the share of 25+ cars in total emissions depends on the absolute emissions of these cars from absolute emission of all cars. If total emissions of modern cars decrease , this would result in an increase in the share 25+ cars in total emissions, even if the their emission levels remain constant.

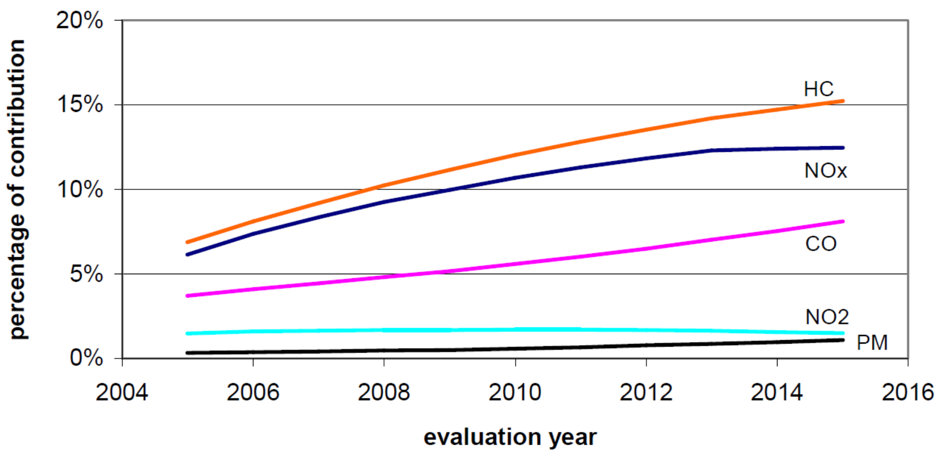


**Figure 2 Annual contributions of passenger cars 25+ years to the overall car emissions Source: Rijkeboer (2008)**

The above findings of Rijkeboer's study somewhat conflict with findings of a more recent (2012) study conducted by Dutch Environmental Assessment Agency (Planbureau voor de Leefomgeving – PBL). The PBL study concludes that in 2011 emissions of cars above 25 years are nearly three kiloton of nitrogen oxides ($NO_x$) and 0.2 kilotons of particulate matter (PM10). These have a share of 10% in $NO_x$ and 5% in PM10 emissions of all cars in 2011.

Furthermore it is forecasted that in 2015 the share of 25+ years old cars from $NO_x$ and PM10 would rise to 15% and 5% respectively. This increase in the share in emissions is not so much the result of an increase in emissions from older cars but due to decline emissions from modern cars (Hoen et al., 2012). Due to recent fiscal changes in the Netherlands ownership of some categories of HVs has become less attractive, and consequently the numbers of cars in those categories declined, mainly due to exports. Therefore the PBL scenario for 2015 very likely will not materialize.

Another recent study by IFEU (2013), using the so called TREMOD emission model estimated emissions of all transport for the period 1960-2011 for Germany (IFEU, 2012). Using data for distance driven and total fleet emissions for $NO_x$ and PM10, we calculated emission factors for the car fleets of 1960, 1970 and 1980, relative to the 2011 car fleet. Table 4 shows the results, which are merely indicative, firstly because we derived values visually from figures, and secondly because emission

[5] HC stands for hydrocarbons shortened to HC and refers to emissions from various unburned mixtures of hydrogen and carbon in fuel and rarely, oil.

factors for fleets of decades ago are relatively uncertain. Therefore they are not more than a very rough estimation of trends in per kilometre car emissions.

**Table 4 Emission factors of all passenger car fleet for NOx and PM, Germany, 1960-2011 Source: IFEU (2013)**

| Year | $NO_x$ | PM10 |
|---|---|---|
| | index 2011=100 | |
| 1960 | 583 | 163 |
| 1970 | 585 | 166 |
| 1980 | 611 | 197 |
| 1990 | 434 | 251 |
| 2000 | 178 | 212 |
| 2011 | 100 | 100 |

The figures in table 4 do not only reflect changes in vehicle characteristics, but also in usage patterns (e.g. share of urban roads and motorways). Between 1960 and 1980 per kilometre emissions of $NO_x$ remained quite stable. But from 1980 we observe reduction of $NO_x$ to about one sixth of those in 1960-1980. Per km emissions of PM even increased between 1960 and 1990 but dropped since 1990 to about 40% of those in 1990 in 2011. It is important to realize these are fleet average emission factors, not those for new cars. New cars in 2011 have much lower emission factors than those of the whole car fleet.

$NO_x$ is a type of emitted gas from Vehicle engines which is a mixture of nitrogen monoxide (NO) and nitrogen dioxide ($NO_2$). For health $NO_2$ is a problem, NO is not. Before the introduction of three way catalytic converters on new petrol cars (starting around 1987, with a share of 100% since 1993) the share of $NO_2$ in total $NO_x$ emissions was relatively low (5-10%). Cars with a three way catalytic converter have a share of $NO_2$ for up to 55%. We conclude that the difference of $NO_x$ emission factors between historic petrol cars and modern cars is much larger than the difference in $NO_2$ factors. Consequently the decrease in the harmful $NO_2$ emissions is much less than the decrease in $NO_x$ emissions (Hoen et al., 2012).

There is another issue about PM that we need to point out in here. Older diesel engine vehicles emit more PM than newer engines (Twigg, 2007), but modern vehicles have a higher share of ultra small particulates (e.g. PM2.5) in total PM emissions, and these ultra fine particulates have relatively more negative impact on human health than PM10 (Gertler, Gillies, & Pierson, 2000).

### 6.1.2. $CO_2$ emissions

Unlike for PM, $NO_x$, CO and HC, there are no per km emission standards for vehicles for $CO_2$. Nevertheless the EU did implement $CO_2$ policies (European Commission 2012 - IP/12/771) to reduce $CO_2$ emissions from new cars and vans by 2020 to (on average, and measured under test conditions) 95 (gr/km), and to 130 (gr/km) in 2015, whereas these were (on average) 137.5 (gr/km) in 2011. The USA target for 2025 is to reduce $CO_2$ emissions to 143 (gr/mile) (Davis et al., 2014).

An important question is: How do per kilometre $CO_2$ emissions of HVs relate to recently build vehicles? There is hardly any literature on this topic for all HVs. The only literature that we are aware of, relates to cars.

Based on the IFEU (2013) study, and implementing the same technique that was used to derive table 4, we calculated indicatives for $CO_2$. Table 5 shows that between 1960 and 1980, $CO_2$ emissions per car km increased by about 10% in Germany. Since then these decreased by about 20%. We repeat that these figures relate to fleet averages in real world conditions, and not to new cars under constant conditions.

**Table 5 Emission factors of the car fleet for $CO_2$, Germany, 1960-2011 Source: IFEU (2013)**

| Year | $CO_2$ (index 2011=100) |
|---|---|
| 1960 | 114 |
| 1970 | 122 |
| 1980 | 126 |
| 1990 | 119 |
| 2000 | 110 |
| 2011 | 100 |

An exception to the trend shown in table 5 is the fuel efficiency of cars of USA brands. In the USA fuel efficiency of cars used to be way lower than in the EU. The difference is as much as 100% between 1985-2010 (Nemet, 2012), for several reasons, one reason being the low prices of petrol (due to the absence of levies on petrol). The so called Corporate Average Fuel Economy (CAFE) standards that were introduced in 1975 (in the wake of Middle East oil crises) aimed to improve fuel economy of cars. This can be seen in figure 3.

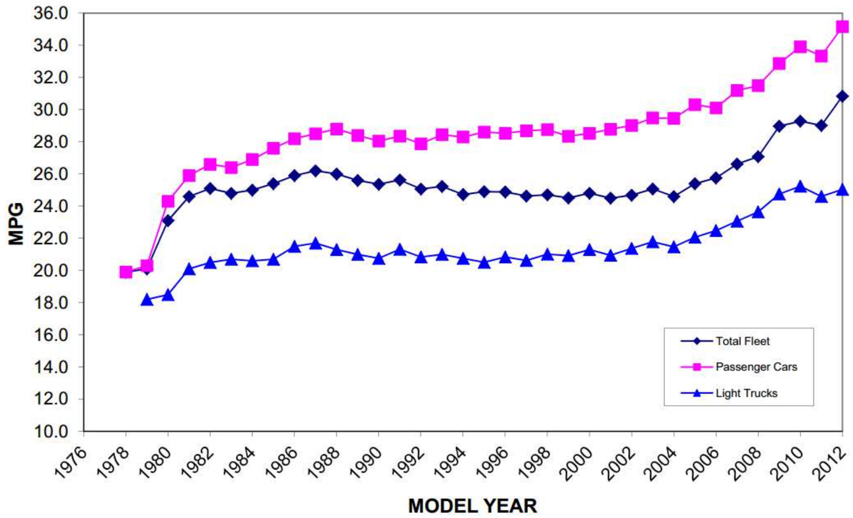


**Figure 3 Overall vehicle fuel econmy trend line in USA since introdcution of CAFE regulations. Source: Anderson (2013)**

The difference in fuel economy and subsequent $CO_2$ emissions between US, EU and other Asian countries is clearly visible in figure 4 below[6]. For instance average US cars were driving approximately 28 mile/gal whereas the EU cars were around 43 mile/gal and Japanese manufactured cars were even better by driving 46 mile/gal in 2010.The International Council on Clean Transportation published this graph on global passenger vehicle fuel economy and Greenhouse gas emissions (GHG) in April 2010.

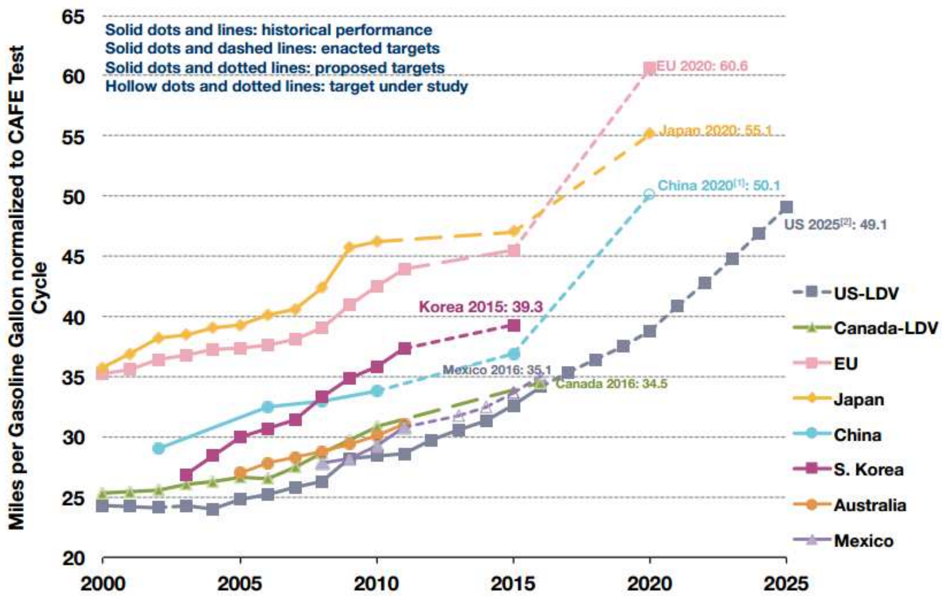


**Figure 4 Comparison of fuel economy of cars made by different parts of world, source: ICCT (2010).**

Van den Brink and Van Wee (2001) studied new car energy use and $CO_2$ emissions. They conclude that between 1985 and 1999 in the Netherlands the car fleet did not improve its fuel efficiency. All ‘gains’ due to technical progress were compensated by a shift towards larger, heavier, more luxurious (air conditioning) and more powerful cars. Furthermore, Nijland (2014) concludes that under test conditions $CO_2$ emissions of new cars have significantly decreased (since 2008 around 30%), but real world emissions decreased much less. The difference between real world energy use and $CO_2$ emissions is increasing over time, from less than 10% in 2001 to 20-30% in 2011, which expresses the poor correlation between test conditions and real world conditions.

Not only driving a car emit $CO_2$, so does producing a car. Nowadays most materials of scrapped cars are recycled. The share in $CO_2$ emissions of producing a car, including the ‘gains’ due to recycling is estimated to be in the order of magnitude of 15-20% of life cycle emissions (Van Wee, Moll, & Dirks, 2000). In the past several countries have introduced scrapping schemes for cars, arguing that new cars are more fuel efficient than other cars (Van Wee et al., 2011). But because producing a car also takes energy, energy efficiency of new cars needs to be much higher than real world improvements during the past decades, for scrapping schemes to reduce life cycle $CO_2$ emissions (Van Wee et al., 2000). Every additional year a car lasts does not increase its energy use for production.

We conclude per km $CO_2$ emissions of HVs are somewhat higher than those of the current car fleet. The difference probably is in the order of magnitude of 10-20%, and varies between EU member states. Since the order of magnitude of the decrease of $CO_2$ emissions per km and the share of

[6] (Source: http://www.eenews.net/special_reports/The_Race/stories/1059970588)

production related $CO_2$ emissions in total emissions are about equal, we conclude that on a life cycle bases the $CO_2$ emission of historical cars is in the order of magnitude of those of modern cars. However, historic cars have much lower use levels, per vehicle annual $CO_2$ emissions are way lower than those of modern vehicles.

Note that maintenance and restoring a HV also results in $CO_2$ emissions, which has not been included in above discussions. To the best of our knowledge there is no literature on this topic.

### 6.2. Noise

According to Sandberg (2001), Germany is one of the first countries which has implemented regulations for vehicle noise as early as 1937 and these regulation were updated in 1953, 1957 and 1966. However, international actions to control or lower vehicle noise levels did not come into effect until 70s (for motorcycles this was as late as 1980). The measured data on noise pollution indicate that annoyance from vehicle noise has only started to decline since mid-80s (Sandberg, 2001). Mais (2014) also confirms that the initial EU regulations for noise emissions of cars were introduced in 1970. Since then noise emission standards were periodically updated. However, test conditions were also modified, which resulted in strongly reducing the potential effects of more tight standards.

In addition, the share of noisier diesel cars in EU auto fleet has increased significantly over the past decades. In practice between the mid-80s and mid 2000s, per km, noise emissions of new cars in the Netherlands did not decrease significantly, and those of lorries decreased by only 3-4 dB(A), way less than the change in maximum noise emissions under test conditions (Mais, 2014). Consequently, differences in per km noise emissions of historic cars and more recently build cars will be very small.

### 6.3. Environmental Zones

The introduction of environmental zones in around 200 towns and cities in more than 12 European member states[7] may have direct consequences for HVs. The environmental zones (more precisely) labelled as 'low emission zones' (LEZ), according to the Directorate General for Mobility and Transport of European Commission, are defined as: "areas where access by vehicles is limited by their emissions … to improve air quality". From the information retrieved from the EU Mobility and Transport Directorate, various cities with LEZ require vehicles to be used in that zones to comply with different emission standards ranging from Euro 1 up to Euro 4 emission standards, by year 2014.

These environmental zones are designed to protect crowded urban areas from polluting vehicles. Per kilometre emissions of pollutants ($NO_x$ and PM10 being the most important) HVs are much higher than those of modern vehicles. Consequently some cities have restrictions on the use of HVs. On the other hand, HV have only a small share in vehicle miles driven (see section 5: about a quarter of a percent). In section 6 we discussed the findings on HV emissions in general. An interesting question, however, is: How large is the share of HVs in (local) emissions in build-up areas?

Hoen et al. (2012), referring to a study of Klein et al. (2012) report that cars over 25 years have 40 times higher $NO_x$ emission factors in the build-up area, and even 100 times higher factors outside the build-up area. A diesel car manufactured in 1986 emits 80 times more PM10 than a new diesel car. $NO_x$ emissions mainly are emitted by petrol cars, PM emissions by diesel cars (Hoen et al., 2012). At the fleet level the differences are smaller, but still high. As explained above the current car fleet in

[7] Derived from http://urbanaccessregulations.eu/ website affiliated with the European commission

Germany produces about one sixth of per km $NO_x$ emissions, and half of per km PM emissions, compared to the 1980 car fleet.

With the aim to improve air quality in cities the Dutch PBL study investigated the effect of a nationwide stringent scheme of environmental zones, in which pre-1989 cars are not allowed to be driven in all build-up areas. Note that such prohibition zones are much larger than those that currently exist for lorries in the Netherlands. The scenario therefore studies maximum effects of zoning schemes. According to this study, implementation of such environmental zones for HVs can reduce $NO_x$ emission by up to 2 to 2.5 kilotons  and particulate matter (PM) emissions by up to 0.1 kilotons, annually. The number of locations with too high (compared to the standards) $NO_2$ concentration will then decrease by 5%. For PM10 this decrease is absent because in 2015 even without environmental zones there are hardly no locations left with too high concentrations (Hoen et al., 2012). The authors emphasize the effects are upper bound estimates because they assume old vehicles will not at all be used anymore, also not outside the build-up area. If 'only' kilometres driven by pre-1989 cars in the build-up area would disappear, the decrease in $NO_x$ emissions is 0.5 kiloton, and the decrease in PM10 emissions less than 0.1 kiloton.

## 7. Safety considerations

Both active safety (brakes, handling) and passive safety (crash worthiness) of cars, vans and lorries have improved significantly since 40s, partly due to regulations, but also because of improvements made by the car industry, the introduction of crash zones and seat belts by Volvo and others being well known examples. So at first glance one would expect HVs to have relatively high per kilometre crash rates, and to have higher fatality rates, not only per km but also per accidents. However, research findings do not verify this hypothesis.  A German study of the Technical University Dresden (Liers, 2013) reveals that per vehicle, historic cars have 8 (2010) to 9 (2011) times lower  per car accident rates. Per kilometre driven accident rates are 2-3 times lower. The fatalities rate per car is 8 (2010) to 5 (2011) times lower than average. Note that the numbers of fatalities per kilometre are too low to derive statistically significant conclusions. Because historic cars are driven way less than average per year (about one sixth), the fatality rate per kilometre of historic cars and all cars must be in the same order of magnitude. In other words: the lower safety level (crash worthiness, handling) and lower accident risk per kilometre of historic cars roughly balance out.

How can we explain this contradiction? Again no previously published literature was found on this topic, so we refer to own experience and several contacts with HV enthusiasts to reason low accident rates for HVs. The explanation is probably in the way historic cars are used. To protect their cars, HV owners drive more than average in favourable weather conditions – they do not want to expose their vehicles to bad weather. Convertible historic cars generally leak water, making them less attractive to drive under rainy conditions. HVs are hardly used in winter and therefore they are rarely exposed to slippery conditions. Many owners do not use their vehicles in the winter season, keeping them dry in garages over winter.

Furthermore, HVs are used less than average in congestion, for a host of reasons:  firstly because their use is often related to (weekend) events, secondly because several insurance companies exclude commuting, and thirdly because HVs were not designed to be used under conditions of heavy congestion as a result of which their engines can easily overheat (the cooling system has a too low capacity to deal with heavy congestion).

Focusing on fatalities, overall it seems that driving behaviour compensates for the below average passive and active characteristics of HVs. For other accidents (non-fatal) driving behaviour more than compensates these characteristics. The importance of driving behaviour for accidents is confirmed by academic literature. Martens (2014) referring to Rumar (1985) concludes that the driver contributes to 94% (fully or partly) of all accidents and the malfunctioning vehicle contributes to 12%. Note that there is overlap because some accidents have multiple causes (Martens, 2014).

The importance of driving behaviour can be further illustrated by an example case from USA. In the 1970 the US government considered to forbid convertibles. Triumph therefore decided to design the successor of their TR6 convertible sports car, the TR7, as a coupe, not a convertible (http://www.classicandperformancecar.com/buying/octanebuyingguide/282442/triumph_tr7_tr8_buying_guide.html; http://www.bmh-ltd.com/triumph.htm ). But the intended policies were not implemented. Unofficial sources reported that research revealed that fatality rates of convertibles were not higher than those of other cars, firstly because with the roof off visibility is excellent, and secondly because convertibles were driven more carefully. Consequently Triumph decided to also launch a convertible version of their TR7, though years later than the coupe.

There is another indication that underpins our conclusion that HVs seem to have lower accident rates than modern vehicles, which is the existence of very special and cheap insurances for HV owners. For instance, in the Netherlands several companies offer insurances for as little as 50 euros (roughly $64 USD) per year for older cars (e.g., http://deoldtimerverzekering.nl/). The low premium set by market based insurance companies expresses the low accident rates on a per vehicle basis, but not necessarily on a per km basis, since HVs are used way less than modern vehicles.

## 8. Congestion in urban/suburban areas caused by HVs

Providing and improving accessibility is the core focus of ministries of transport, and of transport policy making at the local and regional level. One of the ways in which policy makers can improve accessibility is by reducing congestion, both at the urban and interurban level.

An important question from the perspective of this report therefore is: what is the impact of HVs on congestion? Only analytically we can provide a discussion for this topic because we did not find any related literature.

As presented above, we estimate the share of HVs in overall vehicle kilometres to be around 0.25%. So a first rough estimate would be that HVs have a share of 0.25% in congestion. However, we think the share is probably (way) lower, for several reasons. First of all, many owners do not use their HVs on a daily basis. For instance in the FEHAC survey less than 10% of respondents (from a total of 8000 HV owners) reported daily use which was defined as more than 3 times per week (FEHAC, 2012). In addition, HV owners use their vehicles relatively frequently for events (see section below, positive effects of HVs), which are generally organized during the weekend.

Secondly, based on expert judgments, most owners have a modern vehicle available. Thirdly, many owners mainly or exclusively drive under conditions of good weather, whereas bad weather contributes to congestion (Koetse & Rietveld, 2009). Fourth, many HV do not have a cooling system that is adequate for conditions of severe congestion, which discourages owners from driving under such conditions. Putting all these reasoning together, one can conclude that it is likely that the share of HVs in congestion is certainly lower than 0.25% and therefore negligible.

# 9. Positive effects of HVs

## 9.1. Social effects

Not only do owners of HV enjoy these vehicles, so do many others. According to the official view point of the European Union, reflected in DIRECTIVE 2014/45/EU, classic vehicles are preserved for heritage purposes and also bear a resemblance to an era or historical period (e.g. industrialization, steam age, WW II or, 60s etc.) in which they were manufactured. Moreover, HVs help to keep memories alive in the minds of people and motion picture industries often need to use HVs in movies to effectively reconstruct scenes from past decades. Moreover, vintage vehicles and their enthusiasts are present in recreational activities, charitable events, HV racing occasions, celebrations, weddings, and formal events (e.g. military parades), indicating a public acceptance of their presence and maybe even public support for such vehicles. Therefore, one can conclude that HVs have some social benefits by playing a role in cultural activities and also by being present at historical events (e.g. war memorials) and even contributing to different occasions in modern life (e.g. in commercial advertisements or even political or non-profit campaigns).

Regarding the emotional bonding between HVs and their owners, an academic article written by Nieuwenhuis (2008) provides an interesting case study. The focus of that paper is about extending the life span of cars (as a durable product) for environmental purposes, instead of scrapping them and purchasing new cars. The case of historic vehicles has been presented as a distinct example of consumer-product relationship, whereby the emotional relationship between owners and their vehicles result in enhanced durability of the vehicle thus guaranteeing prolonged usage of the vehicle (Nieuwenhuis, 2008). Other interesting points raised by the mentioned article are the response of 1669 readers of a popular classic car magazine about reasons for popularity of HVs. The first and most popular reason was about “enjoying” from owning “unusual car”. The second reason was: “Having the satisfaction of being able to fix the car” and the third reason was about “finally” owning and driving the car that they dreamed in childhood.

## 9.2. Economic effects

Documents published about the HV movements often focus on economic benefits of HVs as their prime positive effects. These economic benefits occur in the form of purchasing vehicle spare parts and paying for services and maintenances of vehicles, spending on related magazines, local clubs and so on, mainly by HV enthusiasts.

Researchers in the University of Brighton in collaboration with The Federation of British Historic Vehicle Clubs (FBHVC) have conducted a series of studies on a few HV related events to measure the economic benefits of HV related gatherings on the local economy (where the event took place). These events also provide recreational opportunities for the residents living within a reasonable distance to the venue of the event. Here we will review some of these reports focusing on benefits resulted in these events.

For the Goodwood Revival event, held since 1998 in Chichester (UK), more than 145,000 people per day have attended either as spectators, local HV club members or as members of the crew and competitors of the Goodwood motor race. People attending the event spent 95,000 person-nights out of home (i.e. contributing to local hotels and logging areas) and 17,500 cars, either modern or historic, arrived at the venue each day. More than 95% of the respondents participating in a related survey (conducted by same research team from the University of Brighton) stated that they would return to the race in the following year. Finally, in 2012, the event generated over £12 million (approximately $19 million USD in 2012) revenue for the local community and £36 million gross turnover for UK economy of which £4 million was VAT (Kaminski, Smith, & Frost, 2013b).

The Beaulieu International Autojumble (held near Southampton, UK) in 2012 generated nearly £3 million for the local economy and over 11,000 person-nights stayed at accommodation in local hotels & guest houses. This event was responsible for over £11 million turnover for the national economy of which at least £570,000 was paid in form of value added tax (VAT) to the government (Kaminski, Smith, & Frost, 2013a).

There are similar reports on other events such as “the London to Brighton Veteran Car Run”, celebrating very early generation of vehicle from 19th century up to vehicles built in 1904 (in 20th century), “The 4th European Healey meeting Crieff” in 2012. These reports also deliver monetary accounts of economic benefits brought to the local community and furthermore emphasise that such events have helped to promote the tourism attractions of those communities and raise the attentions of tourists to travel to those areas.

In a more general report in 2011, again conducted by researchers from the University of Brighton, the whole historic vehicle industry in UK is analysed for its economic returns. The study is based on the interviews from HV enthusiasts, club members, related museums, businesses and workshops which offer services to HV owners. It is estimated that in the UK alone turnover of money due to HV related causes amounts to more than £4 billion (approximately $6.5 billion USD in 2011) annually. This figure has been reported to be £3.2 billion in year 2006 (approximately $5.9 billion USD in 2006) and £1.6 billion in 1997 (approximately $2.6 billion USD in 1997), depicting a solid growth in revenues. Furthermore, the study reports that more than 3800 businesses were involved in supporting HV owners’ requirements for services and maintenance and supplying of parts. Of the companies that were part of the survey, 60% were involved in exporting parts to outside UK and these exports were estimated to have generated £960 million annually. Approximately £70 million was generated by HV museums selling tickets to visitors. Finally, it is estimated that on average each HV owner spends about £2900 for buying parts for their historic vehicle, attending events or purchasing publications related to HV (Frost et al., 2011).

By reviewing the available literature, one may conclude that HVs do generate positive economic effects which are primarily benefiting two sectors in industry: 1) automobile industry and 2) tourism and recreation industries. As a consequence, jobs are created and goods and parts are exported to meet HV owners’ and enthusiasts’ requirements and activities.

Note that the studies that were reported in this section are all executed on behalf of HV interest groups. Secondly it is important to note that turnover has a limited value for estimating the economic benefits. We present an example to clarify this point: let us assume person A sells a car to person B for 10,000 euros, and half a year later B sells the car to A again, with the similar price. Then there is a turnover of 20,000 euros, but in practice nothing changed. Thirdly, if people appreciate watching HVs but do not pay for it (like in a museum), economists call their benefits external benefits: benefits the owner does not (or only partly) include in his decision to own or drive or park his HV. The value of those external benefits adds to those related to expenditures of HV owners.

# 10. Conclusion and Discussion

## 10.1. Conclusions

To best of our knowledge, this study is the first of its kind to review the literature about historic vehicles. The aim has been to conduct this review process objectively and to look at available materials through scientific spectacles. In this section, first we summarise our findings and then we discuss our methodological approach. Next we address gaps that are not yet covered in this study and also point out topics that require further research.

By looking at the literature we saw that the number of vehicles, at least cars, of over 30 years old is growing. This increases the relevance of historic vehicles from a policy perspective. Statistics on HVs are poor. A rough indication is that HVs have a share of 1% of vehicle fleets across the EU. About 90% of HVs are either passenger cars or motorbikes. The share of HVs with respect to vehicle fleets of individual countries are quite different – this share can be as high as 6% or as low as 0.6%. Proper estimates of societal impacts of HVs require good statistics, which are currently missing.

The share of HVs 30+ years old vehicles in total mileages is roughly 0.25%, although some reports show shares of as much as 1.5% in total vehicle use for vehicles 25+ years old. Due to the uncertainty in ownership levels, and only limited availability of reliable “per vehicle use” data, these figures are relatively uncertain.

$NO_x$ and PM10 cause most vehicle related health problems. The German car fleet in 2011 has six ($NO_x$) and two (PM10) times lower per kilometre emissions than the fleet of 1980. HVs have a share of a few percent in vehicle related emissions of those pollutants (not more than single digit numbers). Per kilometre $CO_2$ emissions of the current car fleet is roughly 10-20% lower than cars 30+ years old cars. This difference is roughly compensated by lower life cycle emissions, since producing a car also costs energy and results in $CO_2$ emissions. Per vehicle yearly emissions of cars over 30 years old are way lower than average modern cars because HVs are used less frequently.

There is no literature or data on the impact of HVs in congestion. We expect the contribution of HVs to congestion to be less than the estimated 0.25% share of these vehicles for total kilometres driven.

There is no question that historic vehicles are less safe than modern ones. However, given the low accidents/fatality rates per kilometre driven, we conclude that the climate conditions these vehicles are driven and conservative driver behaviour (mainly due to the emotional attachments to the HVs) compensates for HVs’ poorer safety levels.

HV related expenditures have economic benefits, but there is hardly any literature useful to express this in terms of the share in GDP or employment. In addition HVs have so called external benefits for the wider public: people who do not pay for HVs meanwhile enjoy watching them.

## 10.2. Gaps in literature

The initial aim of this study was to review scientific literature regarding HVs as much as possible. Due to lack of scientific literature we included 'grey' literature and research findings which were not peer reviewed but written by academic authors or by research institutes.

During our review process we sometimes faced contradictory statistics and figures which made it difficult to draw up a certain conclusion on some issues. Therefore we were forced to report ranges of numbers on some key issues such as HV ownership, usage and HV emissions. Occasionally, there were altogether no figures or statistics published. For instance, there were hardly any studies on safety and no studies on the share of HVs in congestion. This brings us to the gaps that are not yet studied and requires further work. A deeper analysis on contribution of HVs to congestion and (urban) pollution is required. These type of investigations may lead to a number of interesting findings. An important questions that policy makers and HV enthusiasts are both keen to answer is the share of HVs in congestion and pollution in crowded areas and perhaps in national or international levels. This type of study may assist policy makers to make informed decisions regarding the exclusion or inclusion of HVs in environmental zones or set fair laws and regulation to meet the interests of HV owners and in the same time to avoid or limit HV induced problems.

# Part 2 Advanced data analysis on FIVA socio-economic survey 2014

## 1. Introduction

The socio-economic survey was performed by GfK consultancy group on behalf of FIVA between March and May 2014, by which the information of enthusiasts from 15 European countries were collected. The participating countries were: Austria, Denmark, Belgium, Germany, Czech Republic, Netherlands, Greece, France, Poland, Sweden, Luxemburg, Ireland, Great Britain, Italy, and Spain.

We have used the data set that was provided by GfK from 19432 HV enthusiasts in the 15 member countries. Respondents were able to register information about maximum 5 individual vehicles at 12 different categories of vehicles provided by FIVA.

The initial data analysis was performed by GfK and delivered overall insights over the responses provided by enthusiasts and also their vehicles. The information provided by respondents included diverse variables such as: the status of employment of respondents, their age and living area, expenditure on historic vehicles (HVs) per year, total kilometres driven on HV, how many vehicles belonged to them and some detail questions about each vehicles, costs incurred due to ownership of HV, the number of events participated and popularity of manufacturers etc. These can be seen in detailed report from GfK.

In our study, we look at underlying information in deeper layers of the collected data. We search for direct and indirect relationships that are worthy of further focus and investigation for FIVA and also for others such as transport policy makers. This deeper analysis **aims to find the links between factors explaining the ownership and use of historical vehicles and other observed variables in the survey**.

The topics that we will focus in this study include: ownership, usage, costs, safety, congestion in urban/suburban areas, club membership, activities of enthusiasts and HVs' own specifications. We aim to explore which factors contribute to these topics. More specifically we investigate:

- Factors influencing ownership and use of HVs
- Relationships between socio-demographics of owners and expenditure on HVs
- Relation between fuel type and usage of HVs
- Comparison of HV usage and ownership between member countries
- Relationship between spatial areas where people live and HV ownership and use
- Club membership and its influence on owners' expenditure on HVs and kilometres driven per year
- Most important aspect of HV ownership on owners' opinion
- Accident rates of HVs and comparison with accident rates of current fleet of vehicles
- Clusters of owners and their characteristics
- Relationships between latent factors explaining ownership and use of HVs

We report our results both in technical terms to underpin our findings, as well as in non-technical terms so that non-academics can understand these results.

## 2. Methods

Based on the nature of data analysis, we divide the methods section into two subsections: 1) data analyses of variables included in the survey, 2) data analysis of so called latent clusters derived from the survey (more explanation will be given later). In each stage different methods were used and therefore we explain them separately. For a more technical description of the above mentioned methods please refer to appendix A.

Some activities apply to both methods. These include firstly data refinement and selection of topics to be studied. Secondly we apply mainstream statistical analyses methods. With the help of these methods we are able to find out similarities and differences between owners' characteristics, preferences and behaviours which are reflected in their answers to the survey questions. After we finding how characteristics of owners are related to answers on other questions (such as related to ownership and use of vehicles) , we visualize them by drawing graphs or showing figures which make our findings observable and easy to understand.

### 2.1. Data analysis of variables in the questionnaire

In the survey, respondents were asked many questions about themselves, their HV(s), use of HVs, expenditure on HV(s), participation in events and so on. These kinds of topics are translated in so called 'observed variables'. These observed variables provide the basis of all of our analysis.

We explored if and how characteristics of respondents (owners of HVs), such as income or type of area where they live, are related to HV ownership, use, or expenditures. For instance, one can look for the average number of vehicles owned by those respondents that live in rural areas, small, medium or large towns and compare those numbers to see if there are any relevant differences. Or we can explore if HV ownership and use are related to variables such as age, education level, or monthly income.

### 2.2. Data analysis of latent clusters and constructs

A better understanding of factors explaining HV ownership and use can be obtained by looking beyond the easy observable relations between variables as explained above. This can be done in two ways. Firstly we can see if there are clusters of respondents with more or less the same characteristics, and secondly we can see if there are patterns in answers related to HV ownership and use.

We first explain the first way of clustering. By putting together (segmenting) people who answer the survey questions (more or less) similarly, we can identify clusters of more or less comparable respondents, and explore their preferences and behaviour. These are called "latent clusters" of respondents and this type of analysis is called Latent cluster analysis (LCA).

Latent cluster analysis can provide valuable information. It can tell us what sorts of latent groups exist among HV enthusiasts. Based on the findings, it can reveal similarities, mutual interests, and common preferences in each of these subgroups. These results can be useful for policy makers, or people and firms active in the area of HVs.

We now explain the second way of clustering. We selected a number of observed variables together and see if these can be supported by a broader concept which is called “construct”. This concept is not directly measured in the survey but can be implicitly inferred from a set of selected observed variables.  For instance, if we select some variable such as: participating at events, spending nights away from home for events, conducting maintenance on the vehicle, and being a member of clubs, then we can collectively define a concept called “being an active HV enthusiast” which supports these observed variables. So if a person is an active HV enthusiast, that person is highly likely to be part of many clubs or participate at many events. These types of concepts which are latent constructs can be used to test if being an active enthusiast does relate HV use or the condition of HVs. These are some examples of what latent constructs offer if correctly applied on the data set.

## 3. Results of Data analysis on observed variables

In this section we present our findings of the data analyses. We have conducted the analyses at different levels: vehicle level, individual respondent level, groups of respondents (clusters), and country level.

### 3.1. Aggregate view on the vehicle characteristics

As mentioned above these observed variables from the FIVA survey form the basis of our data analysis. At this initial stage, we provide some aggregate data analysis of HV characteristics.

#### 3.1.1. Overview on age range of vehicles registered in the survey

Respondents in the survey have registered how many kilometres they have driven and also how old their vehicles are.  Figure 1 shows the distribution of all HVs together over years of production.

We see that the majority of vehicles are produced after World War II and as we go towards the 50s and 60s their numbers rise and peak in the early 70s. After 1972 the vehicle numbers start to fall until we arrive to early 80s with exception of vehicles manufactured in 1983. Figure 1 shows the

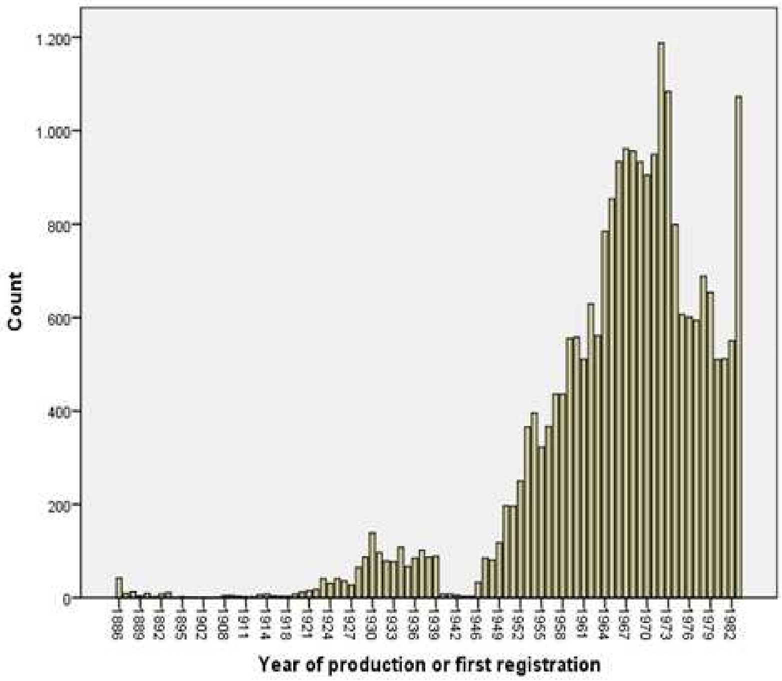


Figure 1 Number of HVs by year of production

number of HVs produced in 1983 to be around 1100. From this information one can say that golden ages of historic vehicles in this sample of owners is the period 1964 till 1974.

Figure 2 shows that the number of young timers (YTs) for the years 1983 – 1987 is in the same order of magnitude, but the number for 1988 is notably higher.

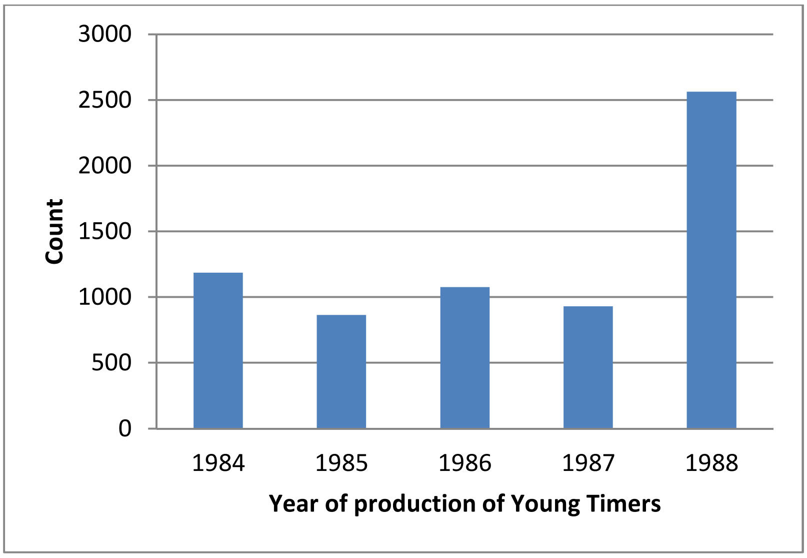


Figure 2: Number of young timer vehicles by year of production

### 3.1.2. Overview of vehicle mileage in 2013

Aggregating the data and looking at self-reported mileages of HV owners, one can see that more than a third of owners (35%) have driven their HVs less than 500 kilometres in 2013. Almost 60% of owners (59%) have driven less than 2500 kilometres and 90% have driven less than 7500 kilometres in 2013. The graph in figure 3 shows these findings at a glance.

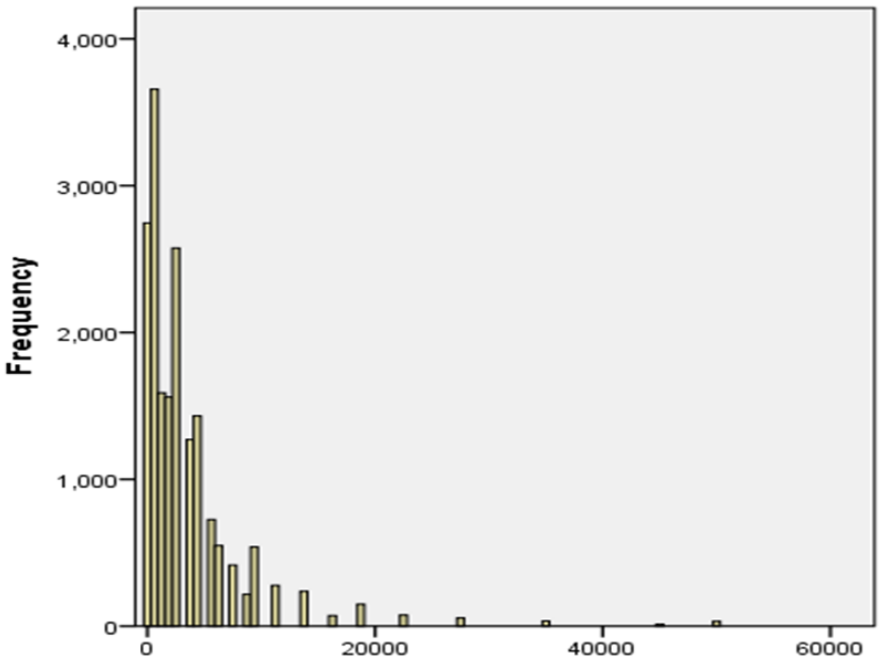


Figure 3: the Kilometres driven by HVs in 2013

Figure 4 shows the results for YTs.  In 2013 more than 50% of young timers were driven up to 1000 km and 67% of all YTs were driven up to 2500 km per year. Another 15% of young timers were driven between 2500 and 5000 km and around 10% were driven between 5000 and 10,000 km or more. Less than 8% of YTs were driven up to 20,000 km or more.

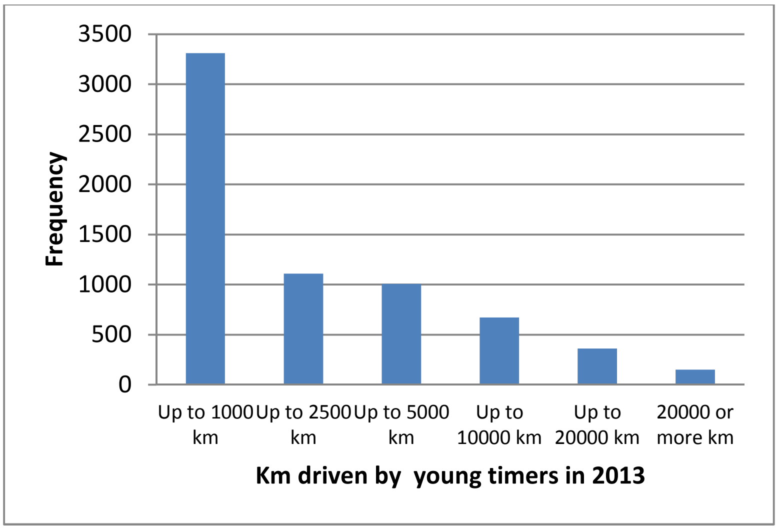


**Figure 4: Counting the average km driven with young timers in 2013**

## 3.2. Different European regions and average expenditure, average kilometres driven on HVs

In the GfK report most variables were compared by member countries. We used these data to see if there is a more aggregate pattern distinguishing groups of countries in expenses and km driven.

We divided Europe into five geographical regions: Northern, Central, Southern, Eastern and Western countries. We assigned Sweden, Denmark and the Netherlands to the Northern countries. Central Europe includes Luxemburg, Germany and Austria, Southern countries include Italy and Spain and to some extent Greece. However, Greece could also be seen as an eastern European country together with Czech republic and Poland. Finally for the western countries we assigned UK, Irelands, Belgium and France. Note that the clustering is not related to geography only, but also to similarities and differences between countries.

Figure 5 show that people in the same region display more or less comparable spending behaviour. For instance, the levels of yearly spending (in 2013) in the Northern countries are from around 6 to 8 thousand euros, whereas in central countries expenditures were much higher, between 10 to more than 12 thousand euros annually.  Southern and eastern countries (with exception of Czech Republic) show low expenditures of on average 4 to 5 thousand euros per year. Respondents in the Czech Republic report high spending but because only 125 respondents have filled in the questionnaire it is questionable to what extent the results apply to HV owners in the Czech Republic in general. Western countries' spending were high: between 7 to 8 thousand euros (which is more than in Northern countries), the exception being the UK in which expenses were on average 13,300 euro's, which is highest of all countries present in the sample. The relatively high expenditures in the UK are probably explained by an overrepresentation of Jaguar owners. Jaguars have the reputation of being relatively expensive to maintain and restore, and to be not very fuel efficient.

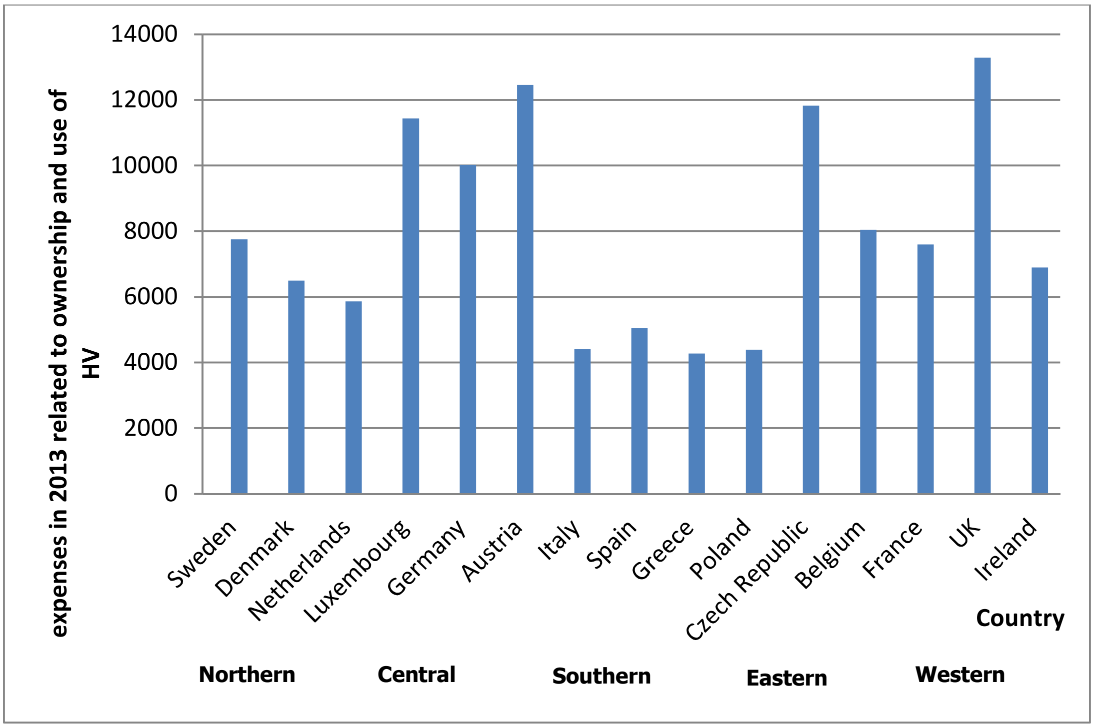


Figure 5: Expenditure of regional countries of Europe on HVs

The picture for the average km driven in different regions of Europe is not quite consistent with the spending. Figure 6 show that Central countries drive most km, more than 4000 km per year. Northern and Western countries drive approximately close to the overall average (3150 km/year) with the exception of Sweden where respondents drive far less than average (1670 km/year) and France where respondents drive around 4000 km/year (about 22% more than average). Another interesting observation is that respondents in Southern and Eastern countries spend less than average on their HV but their mileage is about average or even higher.

Regarding the survey conducted by FIVA and GfK, there are some concerns about representativeness of the respondents. For instance, high estimated market values of the cars in GfK report and the large differences in mileage between different countries can indicate that the respondents may not wholly represent the total HV movement. One possible explanation is that this survey has been distributed via HV clubs and also HV enthusiast magazines, as in the UK example: many Jaguar owners were present in the survey. This can potentially introduce some bias in our analysis towards a certain brand or respondents of an interest group.

From now on, we will focus on respondents' characteristics, and behaviours in relation to their hobby/devotion/commitment to the historic vehicle world.

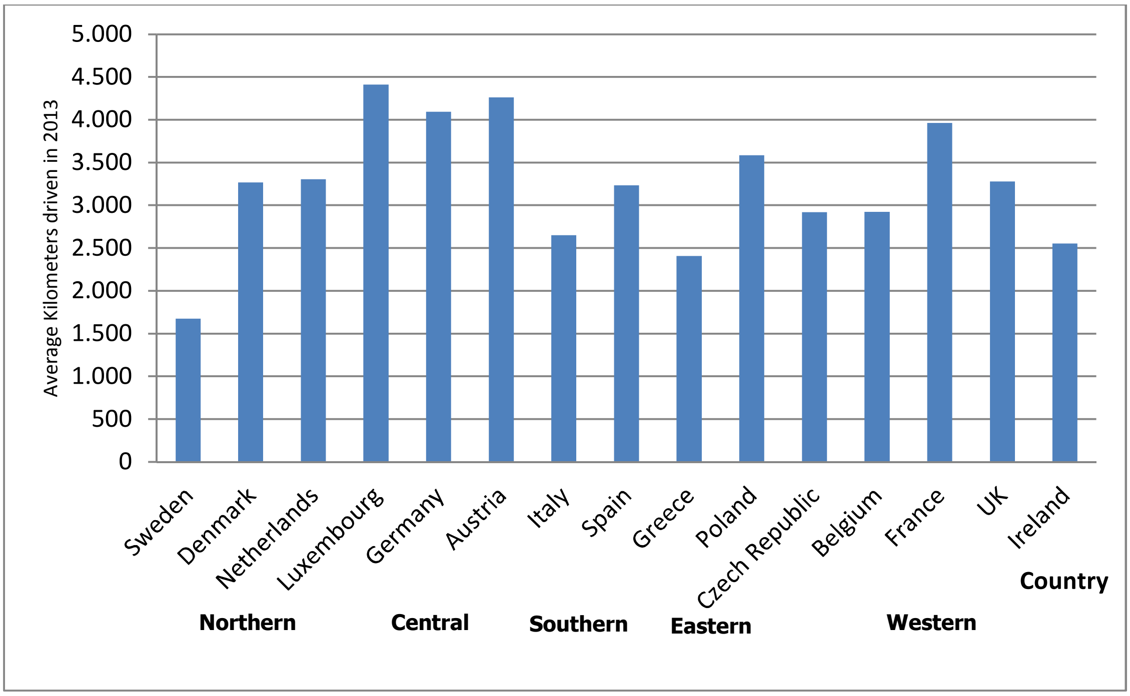


Figure 6: Average km driven in regional EU countries of Europe on HVs

## 3.3. Analysis of different income groups

In the survey respondents were asked about their income level. This provides us opportunity to link respondents' income to HV ownership and usage.

### 3.3.1. Income and the number of HVs owned

The GfK report gives percentages of respondents who belong to different income categories. Here we take a different approach and we compare the income of people who have different numbers of HVs. This means that we want to know what the average income is of those people who have one HV, two HVs, 3 HVs and so on.

The results of above analysis are shown in figure 7. This diagram shows that people with more vehicles on average have higher incomes. Respondents who owned 1 to 4 vehicles, on average had income level between 55,000 and 60,000 euros whereas those who owned 9, and 10 (or more) vehicles earned more than 62,500 euros.

At first glance, one might find it strange that respondents who owned 5 vehicles have a higher income than those owning 4 or 6 HVs. This phenomenon is probably caused by the fact that many respondents have reported up to 5 vehicles in total, whereas they could have reported the information of 5 vehicles *per category*. There were 12 different vehicle categories in the survey: 1) Passenger car, 2) Racing car for circuit racing only, 3) Motorcycle, 4) Moped, 5) Scooter, 6) Camper van, 7) Commercial vehicle under 3500 kg GW, 8) Commercial vehicle over 3500 kg GW, 9) Military vehicle (all weight categories), 10) Bus (other than mini-bus), 11) Tractor, 12) Other self-propelled vehicle for road use. So technically, there was space to fill in the information of 60 vehicles per owner. But as seen from the data set, many owners stopped filling the survey when the information of the 5$^{th}$ vehicle was completed.


Figure 7: Comparing average income of different levels of HV ownership

### 3.3.2. Income and kilometres driven in HVs (HV Usage)

In this section we explore the relationship between net household income and HV use. Figure 8 shows that people with higher incomes tend to drive more, which is in line with intuition. There is another interesting observation in figure 8: respondents with an income below 15,000 euro in a year drive more than average with their HVs. These type of HV owners probably use their HVs as a means of daily transport. We will return on this issue later in section 4.1. of part 2, where we unveil different latent groups of HV owners.

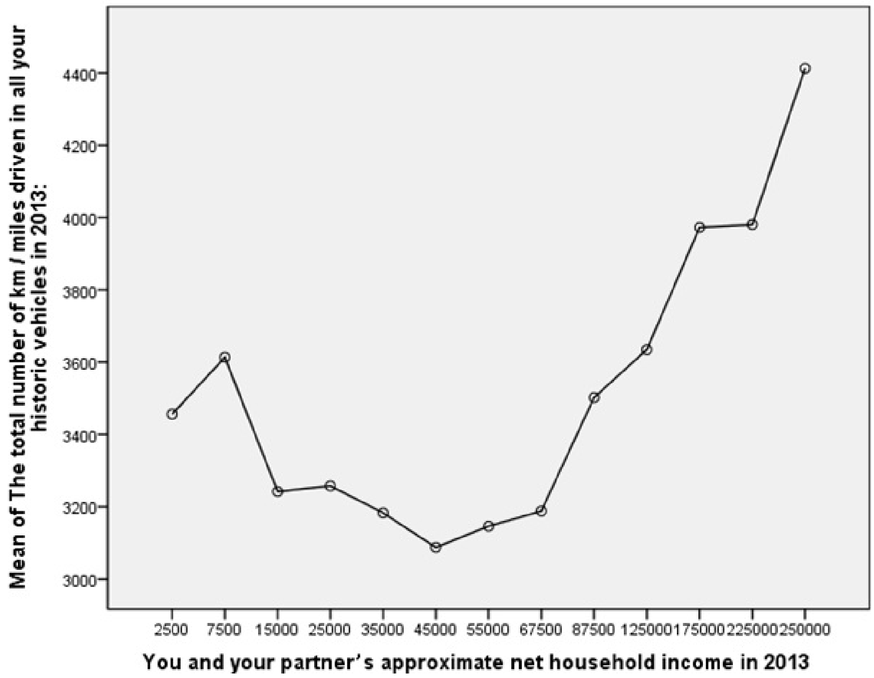


Figure 8: Income categories of HV enthusiasts and average km driven by HVs in 2013

Furthermore, in our analysis we saw that those with a net household income of 30,000 - 70,000 euros, which is a big portion of our respondents (58.6%), drive on average 3100 kilometres per year. People with an income of 70,000 - 90,000 euro drive 3500 km/year and annual use increases even further for people with higher incomes, up to 4100 km/year for those who have a household income over 130,000 euro. People in this income category on average drive 25% more than average. Note that people with higher incomes on average have more HVs, so the use per vehicle will differ less between income groups.

### 3.4. Owners in different spatial living areas

We were interested to see if living area is related in any way to ownership and use of HVs. In the questionnaire people were asked if they are living in large cities (more than 500,000 inhabitants) or towns or rural areas. Given parking limitations and congestion problems in cities we, as a priori, expected that HV ownership and use to be relatively low in cities. Figure 9 shows HV ownership levels are according to our expectations (i.e. lower in populated areas and higher in less populated regions). However, this expectation does not hold for HV use see figure 10.

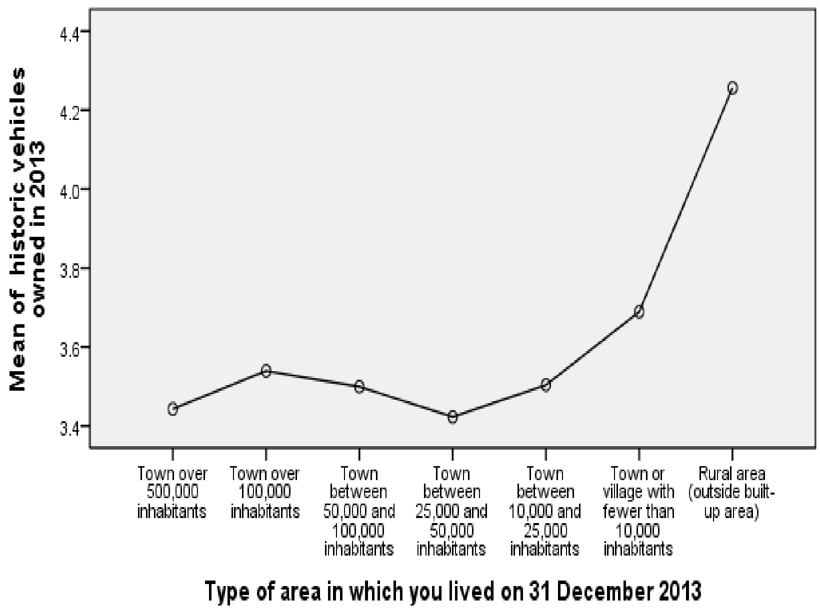


Figure 9: Spatial living places of HV owners and number of cars they own in different areas

Figure 10 reveals that in rural areas and large villages, HVs are driven more than small towns but not as much as in cities.

To conclude this section, we can say that HV ownership in rural areas is higher than in urban areas. Inversely, the usage of HVs in urban areas is higher than in rural areas. Further research is needed to find out the cause for the differences. However, one may speculate that people in urban areas have fewer vehicles because of parking license restrictions. Note that the differences in annual use of HVs between area types are relatively small.

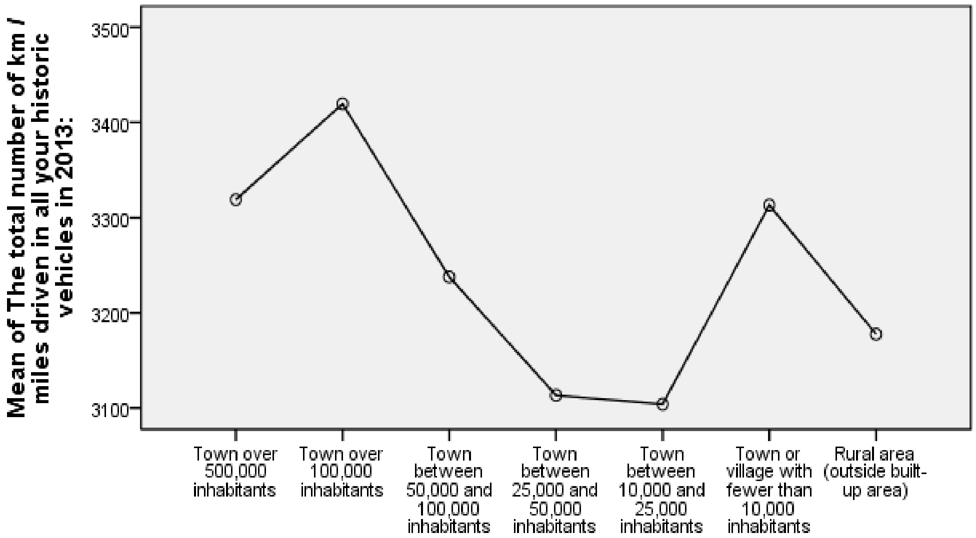


Figure 2: Comparison between spatial living places and km driven by HV enthusiasts

## 3.5. Expenditure on HVs compared with income & age of owners

Previously, we compared expenditures of HV owners of different regions of Europe. In this section we look at expenditures from another angle and investigate how expenditures are distributed according to the net family income of HV enthusiast. Figure 11 shows how much people in different income classes spend on HVs, and reveals expenditures increase as income increases.

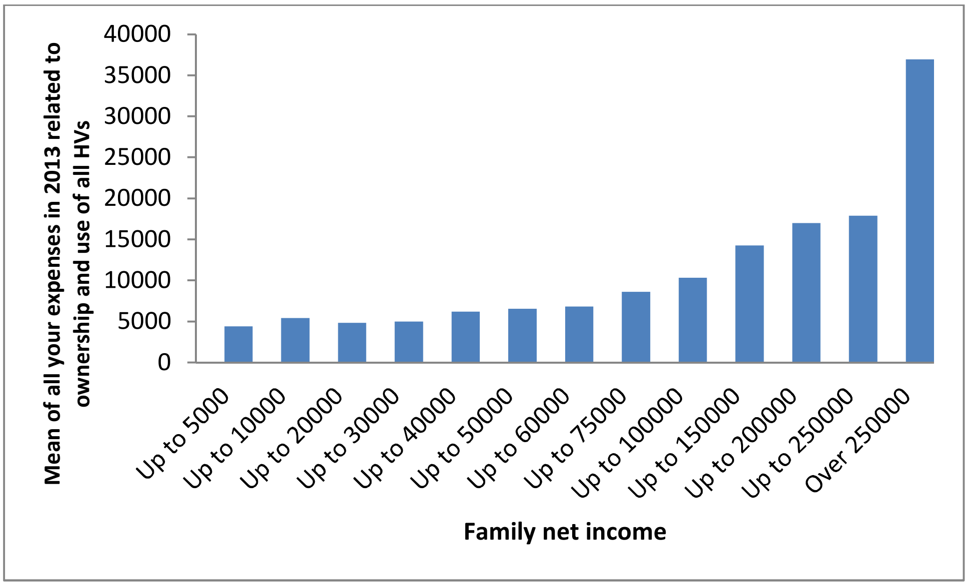


Figure 3: Average expenditure on HVs by income class

Further analysis shows that 88% of owners do not spend more than 10,000 euros on their HVs. Moreover, 27% of owners indicated that they had spent less than 5000 euros in 2013.

Next we explore the relationship between age and expenditures. Figure 12 shows that people born between 1940 and 1960 have the highest expenditures (on average slightly over 8500 euro in 2013). Respondents born before 1940 or after 1960 spend less on their HVs. People in their late 80s spend around 3150 euros (35% of the highest spending group) and people in early 20s spend on average 4350 euros (50% of the highest spenders).

These results can be very significant for FIVA and generally for those HV clubs which operate internationally. These results indicate that HV enthusiasts at best spend around 8500 euros for their HVs and no less than 3000 euros in a calendar year. However for clubs based in specific countries, results of figure 5 can be a better indicator.

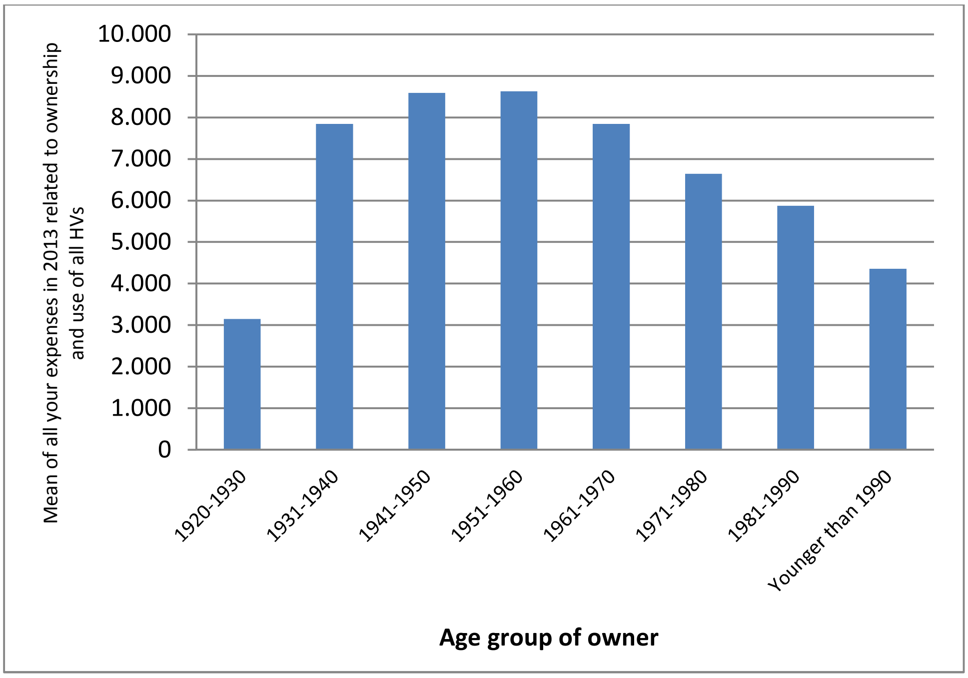


Figure 4 yearly expenditures by year of birth

## 3.6. HV club membership

This section explores if club membership influences average km driven and money spend on HVs in a year. Figure 13 shows that indeed the number of clubs a person is a member of is positively related to yearly use of HVs. Respondents who were member of less than two clubs drove below the sample average and those who were a member of more than two clubs on average drove 4250 km (25% more than average).

Figure 14 also shows that there is a relationship between being member of HV clubs and the amount of spending on HVs. This piece of information might be informative for FIVA in the sense that it may give an indication of the level of activity of HV owners. Those HV owners who are members of more than two clubs on average spend more money and on average drive more with HVs; thus one can postulate that these sorts of people are more likely to be active in the HV community.

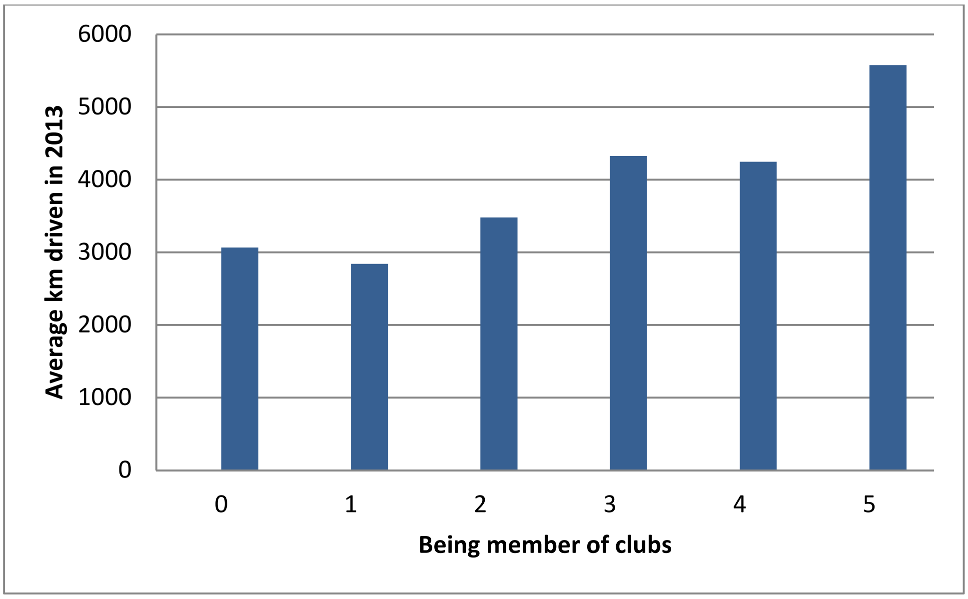


**Figure 5 Club membership and average km driven in 2013**

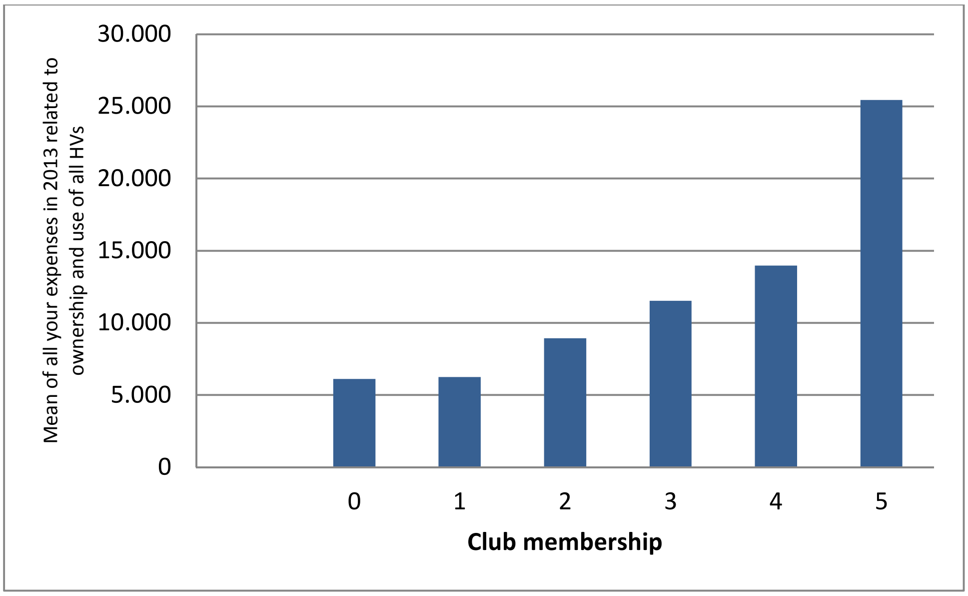


**Figure 6 Club membership and average expenditure on HVs**

## 3.7. Ownership and use of HVs

One can expect that the more vehicles a person possesses the more kilometres that person drives in all of HVs. Figures 15 and 16 show these relationship between ownership and use, for old-timers and also young timers respectively.

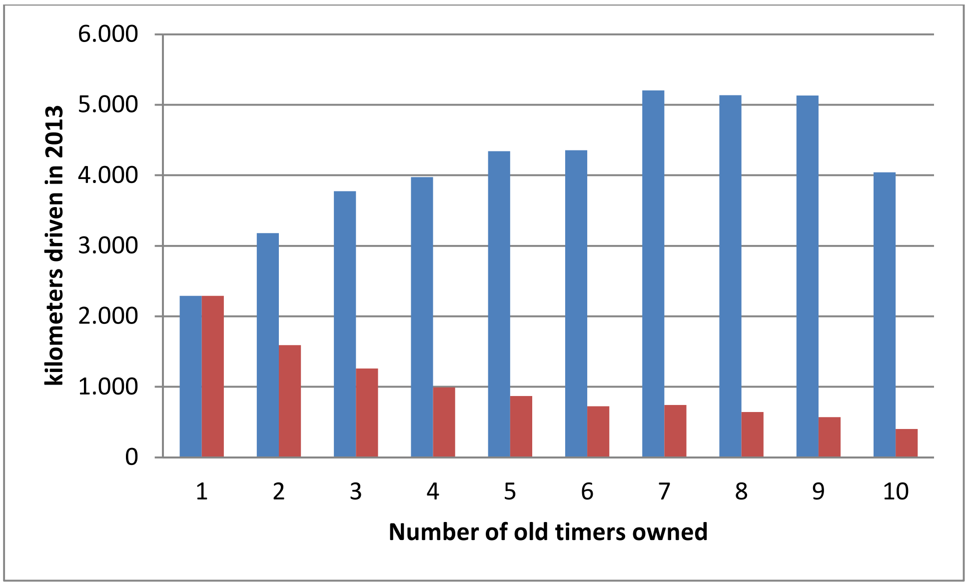


Figure 7: Ownership and usage of old-timer vehicles

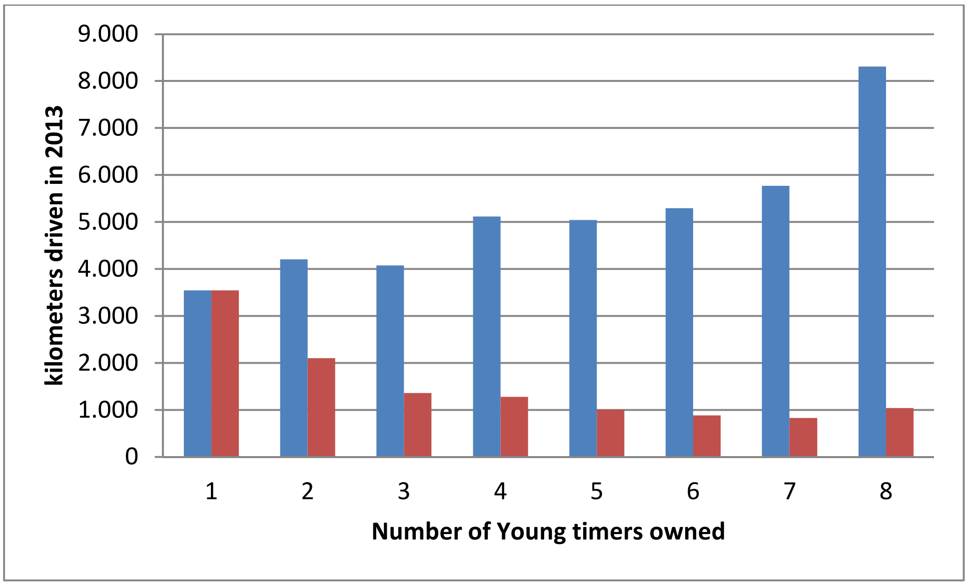


Figure 8: Ownership and usage of young-timer vehicles

As can be seen in figures 15 and 16, two types of bar charts are shown. The blue charts show the aggregate kms driven but the red charts show the kms driven per vehicle. It is apparent that the more vehicles a person owns the high kilometres that person will drive. However, per vehicle, the kilometre driven decreases in a year (on average).

## 3.8. Safety consideration on HVs (data analysis of HV accidents)

In total 20 respondents of the overall sample of 19,432 participants reported an accident involving HVs in 2013 which resulted in casualties. Among these accidents 17 cases involved personal damage suffered by a driver or passenger(s) (0.08%) and 3 cases involved personal damage to third persons (0.01%).

To put these numbers into perspective, in the year 2013 in the UK there were 183,670 cases of casualties due to road accidents (Mais, 2014). There were approximately 35 million vehicles in the UK

(Grove, 2014), which on average drove approximately 12,640 kilometres (7900 miles) per year (Melbourne, 2014). Considering that, this equals to 442 billion kilometres travelled by vehicles, which results to an average of 41.5 injuries per 100 million vehicle kilometres in a year.

The respondents in the FIVA survey reported 58.71 million kilometres driven by 18,265 vehicles in 2013 and 20 cases of accidents involving injuries, implying 34 accidents involving injuries per 100 million vehicle kilometres travelled. Therefore, accident rates of HV owners from this sample of 15 EU member states is around 20% less than accident rates in UK which is has one of the lowest number of fatalities and injuries per 100 million vehicle kilometres of all countries in Europe (Wegman, 2013, based on OECD/ITF data). In year 2012 in the EU on average 1 fatality occurred from road transport per 18,000 people compared to 1 fatality per 37,000 people in the UK in 2013 (Mais, 2014).

Looking further in the survey, we investigated all kind of accidents (material damage and casualties) involving HVs. The tables below reveal that those respondents who reported an accident with their HVs do not belong to a specific age group (table 1) or any particular residential area (figure 17). This means that no significant differences were found in the data set among age groups or residential areas with respect to accidents rates.

Table 3 Counting number of HV owners involved in accident at different age categories

| Age groups of people involved in accident | Share in data (%) | Number of accidents |
|---|---|---|
| Older than 1920-1940 | 18 | 0 |
| 1941-1960 | 35 | 106 |
| 1961-1980 | 36 | 85 |
| Younger than 1980 | 11 | 23 |
| Total | 100 | 223 |

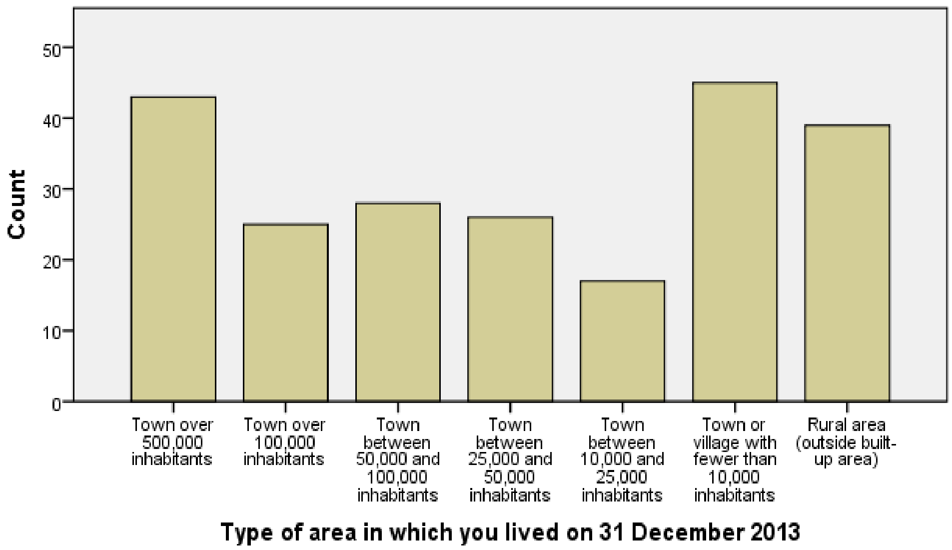


Figure 9 Counting HV owners involved in accident in 2013 based on their living areas

## 3.9. Type of fuel used and average distance travelled per fuel type

One of points of concerns  maybe to investigate HVs' engines with the conventional fuels available in the market.

From the survey data, we were able to see which vehicles used what type of fuel and then compared the average distance travelled by the vehicles.  With did this analysis for passenger cars. Table 2 shows that 96% of passenger cars in the survey had petrol engine. On average the petrol engine cars travelled around 2090 km per year. Diesel and LPG had a share of just below 2%, and the average annual use of these cars is higher than of petrol cars.

**Table 4 Different fuels types and average distance travelled in each group**

| | N | Mean |
|---|---|---|
| Petrol | 29615 | 2091 |
| Diesel | 583 | 3847 |
| Liquefied Petroleum Gas (LPG) | 531 | 3604 |
| Other | 50 | 1990 |
| Total | 30779 | 2150 |

It is possible to conclude that given the average distance travelled per car, owners have regularly used conventional fuels that are readily available at the market. Thus, fuels available today, do not seem to hinder enthusiasts from using their cars.

## 3.10. Results of latent clusters and constructs analysis

As mentioned above, more in depth analysis of the dataset can provide more revealing observations and substantive conclusions.  For this reason, we conducted a second set of analysis that generates latent variables in form of latent cluster and latent constructs.

As implied by their names, the topics investigated in this section are not directly obtained from the survey. The data from the survey is processed to find latent information in it, thus the results in this section are indirectly induced from data. The reason behind this approach is to achieve to a deeper understanding about the preferences, behaviour and characteristics of HV owners.  For instance, in the survey we may not be able to ask directly questions like: "what type of HV enthusiast are you?" But looking at respondents' answers to the survey questions we can categorize them into groups with others who have answered similarly and give them a suitable name that fits best with the characteristics of their groups. This type of analysis is formally called 'latent cluster analysis' and it is frequently  used in market research and consumer behaviour  studies (Hagenaars & McCutcheon, 2002).

## 3.11. Data analysis of latent cluster

We conducted latent class analysis (LCA) for all HV owners in the data set based on six decisive criterions, namely: kilometres driven in 2013, age and income of respondent, number of HVs owned, number of YTs owned and place of living of respondent. These criterions were selected because according to our observations in the previous sections they hold key information about respondents and can determine some essential aspects about their level of enthusiasms, level of spending and participation in HV movement. Table 3 presents the five clusters and their characteristics. The numbers that are provided in this table are estimated based on averaging the answers of all respondents to survey questions.

**Table 5 Five clusters and the values of different parameters conducted for all HV owners (all types of vehicles)**

| Parameters considered for LCA | Class 1 Typical Enthusiast | Class 2 Old-School | Class 3 Antiquarian | Class 4 Regular Transport | Class 5 Collector |
|---|---|---|---|---|---|
| Class Size (%) of total sample 19432 respondents | 13427 (69.1%) | 2545 (13.1%) | 1962 (10.1%) | 1263 (6.4%) | 233 (1.3%) |
| HV mileage in Kilometres per vehicle* | 986 | 965 | 595 | 1419 | 653 |
| Year of birth (mean) | 1960 | 1947 | 1959 | 1984 | 1960 |
| Family income in euros | 63256 | 39416 | 62839 | 18969 | 65908 |
| HV ownership (Mean)** | 2.98 | 3.10 | 9.20 | 2.69 | 10.04 |
| YT-ownership (Mean)** | 1.41 | 1.30 | 1.84 | 1.69 | 8.01 |
| Spatial area of living | | | | | |
| Town over 500,000 inhabitants (%) | 15.41 | 4.67 | 10.77 | 20.8 | 10.38 |
| Town over 100,000 inhabitants (%) | 12.47 | 10.86 | 9.75 | 17.32 | 15.32 |
| Town between 50,000 and 100,000 inhabitants (%) | 9.32 | 8.44 | 7.06 | 8.07 | 9.83 |
| Town between 25,000 and 50,000 inhabitants (%) | 9.97 | 11.87 | 6.95 | 6.94 | 5.55 |
| Town between 10,000 and 25,000 inhabitants (%) | 12.91 | 14.86 | 9.21 | 9.93 | 9.01 |
| Town or village with less than 10,000 inhabitants (%) | 20.42 | 23.42 | 21.24 | 17.73 | 16.75 |
| Rural area (outside built-up area) (%) | 19.5 | 25.88 | 35.02 | 19.21 | 33.16 |

* Please note that these mileages are per vehicle and the average mileage of 3153 km in GfK report is per person.

** These numbers are calculated for all types of HVs owned by a person.

Respondents who appear in these clusters display rather homogenous characteristics regarding use and ownership of HVs. After conducting LCA, we came up with the following 5 latent clusters:

### *Cluster 1 Typical Enthusiast:*

This group is seen as the mainstream HV owner. People in this cluster on average own relatively few young timers, have a relatively high income, live in a small town or in rural areas. Please note that this is a statistical output from our data analysis regarding characteristics of people in this group and not a prerequisite to be allocated to this cluster.

### *Cluster 2 Old-School Enthusiasts:*

Respondents who fit to this cluster own the lowest number of young timers and have highest average age, so we consider these people as “old-school enthusiasts” mainly interested in old historic vehicles. They have the lowest incomes of people in the older age classes, and live mainly in rural areas and small towns.

***Cluster 3 Antiquarian***:

People in this cluster own a relatively high number of old-timers and drive the lowest kilometres per car. Given the very high average ownership of old-timers, we consider this group as accumulators of HVs, thus “antiquarian”. They have a relatively high income and relative to other clusters prefer mainly live in rural areas.

***Cluster 4 Regular Transport Users:***

People in this cluster have the highest mileage per car and own the lowest number of cars, thus they can be considered as users of HVs for regular transport purposes. These people are the youngest group and have the lowest incomes, and they mostly live in cities and large towns (highest percentages in urban living).

***Cluster 5 Old & Young-timer Collector:***

The people in this cluster drive very few kilometres per vehicle and own the highest number of both old timers and young timers. We call this group “collector”, since they basically own a high number of HVs and YTs altogether, and rarely drive them. They have the highest incomes.

### 3.11.1. More detailed analysis on spending behaviour for the latent clusters

Now that the five latent clusters are presented, we move on to discover more detailed characteristics of the respondents in each one of the clusters. For this purpose we deployed highest probability techniques to assigned respondents to one of the five clusters that fitted most. This is done again based on each person’s answers to various questions in the survey. By following above procedure we were able to understand more about respondents in each cluster. Table 4 summarizes our findings. Please note that due to methodological complexities in the analysis, we only included the answers of passenger car owners for the analysis in this section, seen on table 4. Nevertheless, passenger cars comprise the majority of vehicles in the FIVA survey.

**Table 6: common spending behavior of passenger car owners in the five clusters**

| | Class 1 Typical Enthusiast | Class 2 Old-School | Class 3 Antiquarian | Class 4 Regular Transport | Class 5 Collector |
|---|---|---|---|---|---|
| Estimated market value (per car) | 21756 | 22723 | 27667 | 7765 | 25046 |
| Total amount of expenses (per car owner) | 7083 | 5694 | 17032 | 4583 | 21450 |
| Kilometres driven in 2013 (per car) | 2237 | 2235 | 1628 | 2862 | 1631 |
| Amount spend on restoration (per car owner) | 1909 | 1600 | 3761 | 1477 | 4038 |
| Total running costs (Maintenance, accessories, insurance, garage, road tax) (per car owner) | 1758 | 1381 | 3171 | 1393 | 4851 |

From table 4, we can see that people in the “Regular Transport” cluster (4) indeed use their cars more often than any other group, 58% more than average. This indicates that owners in this group are young people, who more than average use their HVs as an everyday transport mode. Cars of respondents in this group have the lowest market value, again confirming that cars owned by people serve as a cheap mode of transport.

Table 4 shows that the Antiquarian cluster (3) has the highest valued cars which are mostly antique cars. This is followed by cars in cluster (5), which belong to collectors, who usually compile a valuable set of vintage cars.  Antiquarians (cluster 3) and collectors (cluster5) spend the highest amount per year on their cars and drive them least, compared to other groups. The same two groups also pay the highest amounts for running costs on cars (e.g. insurance, garage, tax, accessories and maintenance) and also spend most money on restorations.

Cluster (1) is the largest cluster among respondents. They on average spend around 7080 euros per year, out of which 1900 euros is for restoration costs and 1750 euros for running costs. These values are slightly more than those found by Gfk study (6562 euros). This difference indicates that car owners on average spend 521 euros more than the overall sample average which includes all vehicle types. Furthermore, people in cluster 1 on average drove 2237 km per year per car, whereas the overall sample of all car owners in Gfk results show that 2484 km was driven. The conclusion is that typical car enthusiasts in cluster (1) drive 10% less than the whole sample of car owners.

### 3.11.2. Brands of cars in different clusters

Tables 5 to 9 show the top 10 most frequently owned car brands in each cluster, out of the 327 brands that were present in the survey. The last column of each table shows the cumulative percentage for the top 10 brands in each cluster. For instance, in Table 5 the top 10 brands include almost 57% of all cars owned by people in this cluster (about 19,300 cars were present in this cluster).

From the following tables we can see that Citroën, Mercedes-Benz, Volkswagen (VW), Volvo, Ford and Fiat are the brands that are common frequently owned in all clusters. Citroën is the only manufacturer that is either the first or second brand in all tables.  Popular British (sports) cars, in particular MG, Jaguar and Triumph, are over represented in cluster 2 (old-school enthusiasts). In cluster 4, regular transport users, brands that have the reputation to be relatively suitable for daily use compared to competitors build in the same period, like Mercedes and Volkswagen, are well represented.

It is important to realize that the results present ownership of car brands by respondents, not necessarily by all car owners in the selected countries. In section 3.2, we already made explicit that in the UK Jaguar owners are overrepresented. In Germany, 31% of vintage car brands belong to Volkswagen, 29% Mercedes and Opel and Ford each around 10%. Under- of overrepresentation is very likely the result of differences in how active HV clubs were in bringing this research under the attention of their club members. Because the respondents are not randomly selected from all HV owners in the selected countries the results should only be used for comparisons between clusters.

Table 7 Most popular brands among enthusiasts in cluster 1, Typical Enthusiasts

| Cluster 1 Typical Enthusiast | Frequency | Valid Percentage | Cumulative Percentage |
|---|---|---|---|
| Citroën | 1591 | 8.2 | 8.2 |
| Mercedes-Benz | 1358 | 7.0 | 15.2 |
| Volkswagen (VW) | 1351 | 7.0 | 22.1 |
| Volvo | 1232 | 6.3 | 28.5 |
| Ford | 1151 | 5.9 | 34.4 |
| Triumph | 997 | 5.1 | 39.5 |
| MG | 939 | 4.8 | 44.4 |
| Jaguar | 900 | 4.6 | 49.0 |
| Porsche | 764 | 3.9 | 52.9 |
| Fiat | 728 | 3.7 | 56.7 |

Table 8 Most popular brands among enthusiasts in cluster 2, Old-School Enthusiasts

| Cluster 2 Old-School | Frequency | Valid Percentage | Cumulative Percentage |
|---|---|---|---|
| MG | 331 | 9.4 | 9.4 |
| Citroën | 293 | 8.3 | 17.7 |
| Jaguar | 244 | 6.9 | 24.7 |
| Triumph | 230 | 6.5 | 31.2 |
| Mercedes-Benz | 222 | 6.3 | 37.5 |
| Volvo | 210 | 6.0 | 43.5 |
| Ford | 162 | 4.6 | 48.1 |
| Volkswagen (VW) | 124 | 3.5 | 51.6 |
| Fiat | 120 | 3.4 | 55.0 |
| Porsche | 117 | 3.3 | 58.4 |

Table 9 Most popular brands among enthusiasts in cluster 3, Antiquarian

| Cluster 3 Antiquarian | Frequency | Valid Percentage | Cumulative Percentage |
|---|---|---|---|
| Citroën | 553 | 11.3 | 11.3 |
| Volvo | 338 | 6.9 | 18.2 |
| Volkswagen (VW) | 285 | 5.8 | 24.0 |
| Mercedes-Benz | 279 | 5.7 | 29.7 |
| Ford | 244 | 5.0 | 34.7 |
| Fiat | 194 | 4.0 | 38.7 |
| Renault | 191 | 3.9 | 42.6 |
| Jaguar | 162 | 3.3 | 45.9 |
| MG | 158 | 3.2 | 49.1 |
| Peugeot | 157 | 3.2 | 52.3 |

Table 10 Most popular brands among enthusiasts in cluster 4, Regular Transport users

| Cluster 4 Regular Transport | Frequency | Valid Percentage | Cumulative Percentage |
|---|---|---|---|
| Volkswagen (VW) | 193 | 14.5 | 14.5 |
| Citroën | 110 | 8.3 | 22.8 |
| Mercedes-Benz | 102 | 7.7 | 30.5 |
| Ford | 87 | 6.6 | 37.0 |
| Fiat | 82 | 6.2 | 43.2 |
| Volvo | 77 | 5.8 | 49.0 |
| Renault | 62 | 4.7 | 53.7 |
| BMW | 60 | 4.5 | 58.2 |
| Opel | 56 | 4.2 | 62.4 |
| FSO | 38 | 2.9 | 65.3 |

Table 11 Most popular brands among enthusiasts in cluster 5, Collectors

| Cluster 5 Collector | Frequency | Valid Percentage | Cumulative Percentage |
|---|---|---|---|
| Citroën | 70 | 11.2 | 11.2 |
| Renault | 41 | 6.6 | 17.8 |
| Volkswagen (VW) | 37 | 5.9 | 23.7 |
| Mercedes-Benz | 36 | 5.8 | 29.4 |
| Ford | 26 | 4.2 | 33.6 |
| Volvo | 24 | 3.8 | 37.4 |
| Opel | 21 | 3.4 | 40.8 |
| Fiat | 20 | 3.2 | 44.0 |
| BMW | 19 | 3.0 | 47.0 |
| Porsche | 19 | 3.0 | 50.1 |

### 3.11.3. The most important aspect of the ownership of HV among clusters

This section deals with an important question asked in the survey from HV owners. Respondents were asked: “What for you is the most important aspect of the ownership of your historic vehicle(s)?” Owners belonging to different clusters had quite different responses to this question. Table 10 below shows the responses of different clusters to the choices given and the percentages of selected answers.

Of the seven reasons listed in the survey (left column in table 10), ‘daily use’ is highest for people in cluster 4 (transport users). ‘Building-up a collection’ is the reason that is mentioned most frequently for people in cluster 5 (collectors). Cluster 3 (antiquarian) people scored highest for ‘maintenance and repairing the HVs’ and old-school people choose recreation as their most important aspect of HV ownership.

Table 12 Most important aspect of owning HV among members of five clusters

| Most important aspect of the owning your HV | Cluster1 Typical Enthusiast | Cluster2 Old-School | Cluster3 Antiquarian | Cluster4 Regular Transport | Cluster5 Collector |
|---|---|---|---|---|---|
| Doing maintenance, repairs, restoration jobs | 18.6 | 18.7 | 27.1 | 26.1 | 26.0 |
| Recreational touring, taking part in events and shows | 43.2 | 45.9 | 30.5 | 34.6 | 23.7 |
| Taking part in rallies or race events | 4.6 | 4.8 | 7.4 | 3.2 | 6.5 |
| Use for daily transport | 2.4 | 1.7 | 1.8 | 6.8 | 0.5 |
| Nostalgia | 28.1 | 27.0 | 22.6 | 22.1 | 23.3 |
| Build-up of a collection | 2.2 | 1.2 | 9.8 | 6.0 | 17.2 |
| Investment (expected value increase) | 0.9 | 0.8 | 0.7 | 1.2 | 2.8 |

Overall, however, one should say that "recreation and taking part in events and shows" dominates almost all clusters as the main reason to own HVs. Moreover, the last raw of table 10 shows that enthusiast do not see their HVs as investments.

## 3.12. Data analysis of latent constructs

The survey makes it possible to answer questions like "what makes an HV owner to be counted as an active owner?", or "what elements generally influence the quality of maintenance of HVs?". To answer such questions we need to simultaneously look at many variables in the survey. The way to do this is through a sophisticated technique called 'Structural Equation Modelling' (SEM).

In this section, we apply structural equation modelling (SEM) to simultaneously examine a set of relationships between various variables in the data set. The advantage of this technique is that we can test influences of several variables on some other variables in one go (Hair, Tatham, Anderson, & Black, 2006).

We further explain the SEM technique for data analysis by providing some examples. If we take a few variables such as: "club membership", "amount of vehicles owned", "participation at events", all these variables together point to one concept: "how active an HV enthusiast is". If a person is an active HV owner then it is highly likely that person participates in events, owns more vehicles, and spends more on restoration and maintenance of vehicles and so on. With help of SEM, we can establish and explore if these relationships exist. Moreover, we can determine which factors really contribute to the level of activeness of HV owners.

We developed an initial structure, as seen in figure 18 below. Please note that notion of "activeness of HV enthusiast" is not directly measured in the survey. Instead SEM allows us to find such aggregate level concept and measure its influences on relevant variables as shown in figure below. This structure shows that "activeness of HV enthusiast" has a positive impact on three variables that were measured in the survey, namely: number of cars owned ($\beta$=0.48), participation in events ($\beta$=0.53) and club membership ($\beta$=0.64). The $\beta$ coefficients describe the size of the impact of the influence and the higher the value, the stronger the impact is.

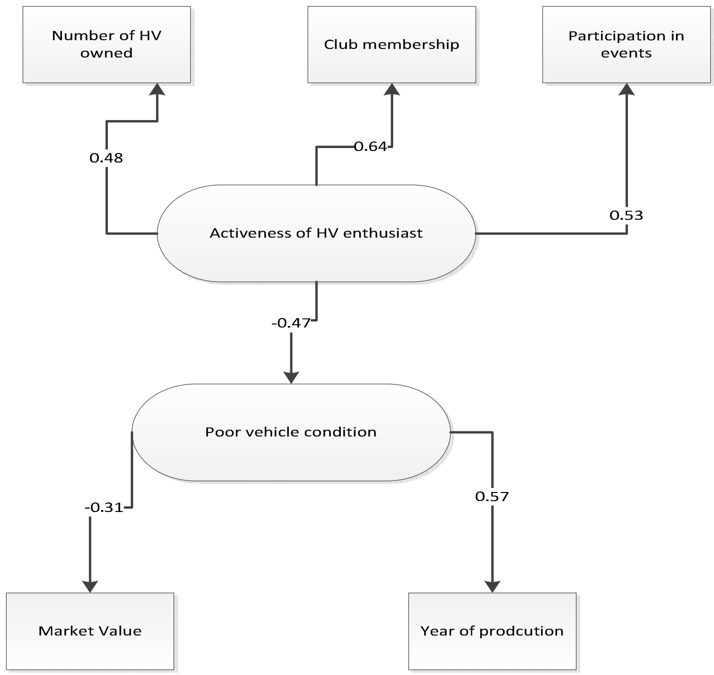


**Figure 10 Latent constructs showing the relation between "activeeness of HV enthusiast" and "vehicle condition"**

Figure 18 also reveals that "activeness of HV enthusiast" has a negative impact on "poor vehicle condition" (β=-0.47). This means that the more a given HV owner is active, the less likely it is that the vehicle of that person is in poor condition. If the condition of the vehicle is poor this has a negative impact on its market value (β=-0.31) and it is more likely that vehicle is old (β=0.57).

In next analysis we introduce a concept called "Adequate maintenance of vehicle" and measure its influence on some observed variables as seen in figure 19 below. From our analysis we see that "Adequate maintenance of vehicle" positively influences the amount owners paid for restoration (β=0.81) and for costs incurred from maintenance (β=0.46) in 2013. Furthermore, we see that past restorations between 2004-2013 (β=0.31) and also costs incurred during this period (β=0.56) are both are positively influenced by "Adequate maintenance of vehicle".

Altogether, from this analysis shown in figure 19, we can conclude that the concept of "Adequate vehicle maintenance" may not be directly asked of owners ( because they may provide subjective answers about the way the maintain their vehicles), however, we can measure this concept indirectly from what they answered to the questions in the survey.

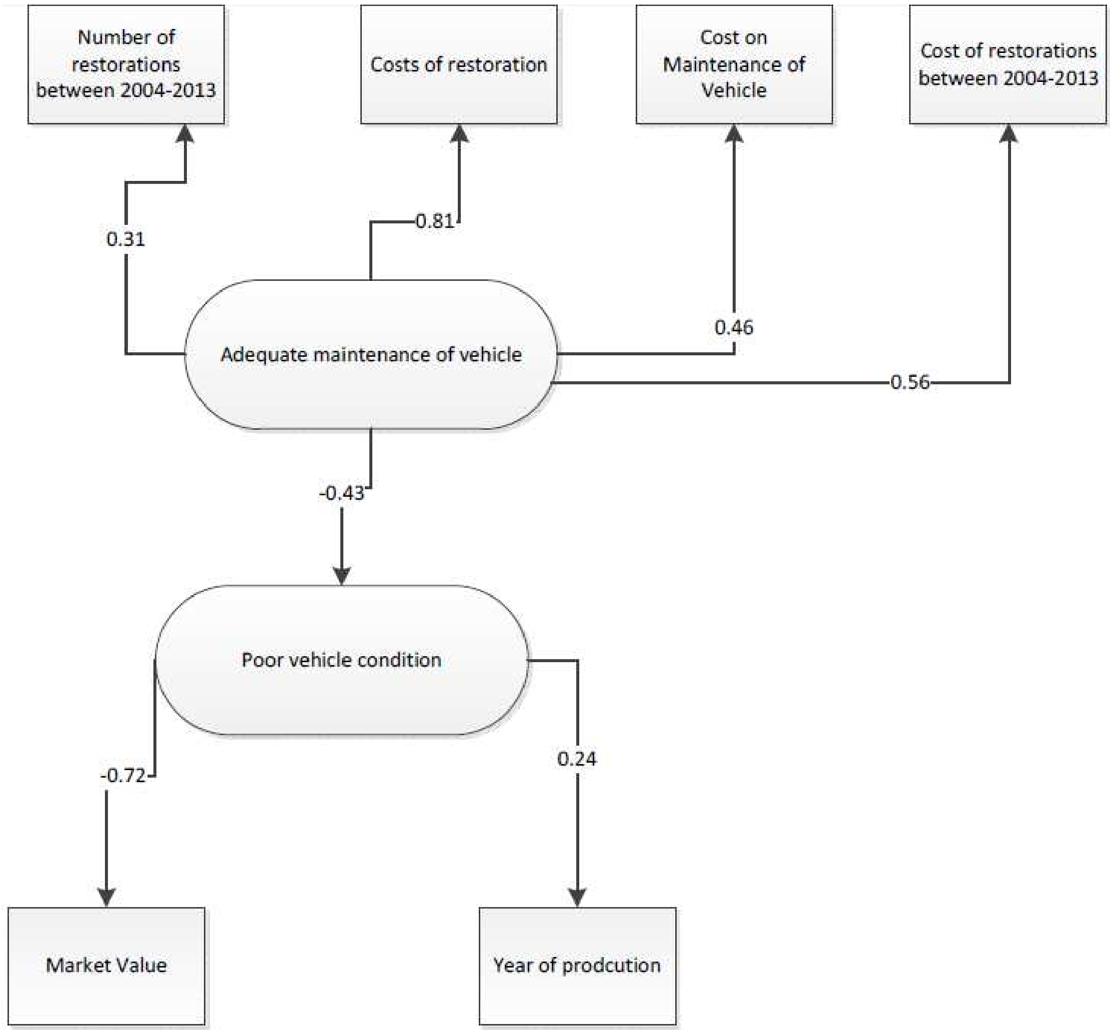


Figure 19 Latent constructs showing the relation between "maintenance of vehicle" and "vehicle condition"

In addition, "Adequate vehicle maintenance" has a negative impact on "Poor vehicle condition" (β= -0.43). In other words: if HVs are maintained well it is unlikely that the vehicles are in poor condition. We can also see that a "Poor vehicle condition" has negative impact on its market value (β= -0.72).

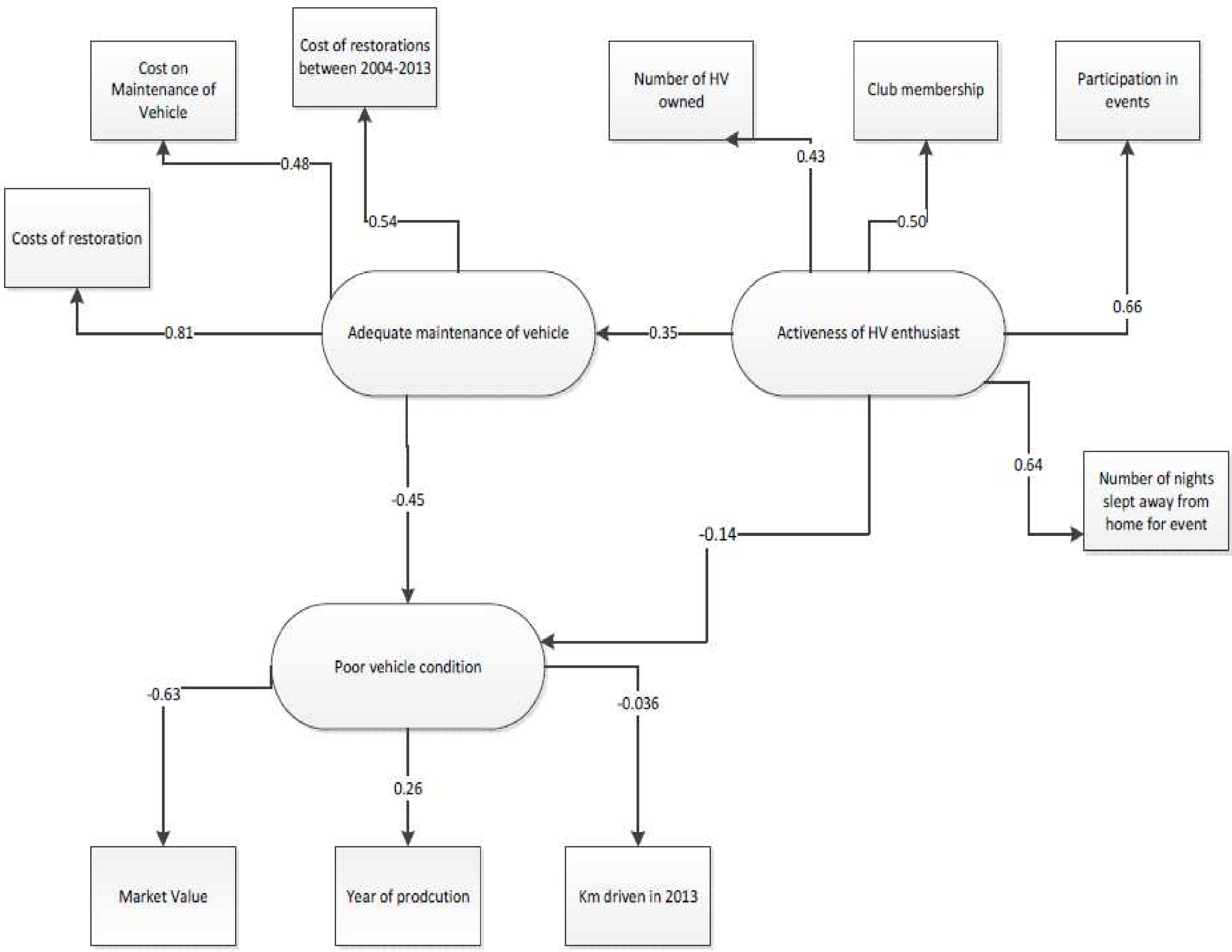


**Figure 11 Latent constructs showing the relation between "maintenance of vehicle", "vehicle condition" and "active HV enthusiast"**

Finally, in figure 20 we put together the two concepts developed before and deliver a combination of the previous two constructs, presented in figures 18 and 19. This comprehensive construct shown in figure 20 tells us that being an "Active HV owner" has a positive effect on "Adequate maintenance of the vehicle" (β=0.35) and in turn this concept has a negative impact on "Poor vehicle condition" (β=-0.45). Although there is a direct negative effect between "Active HV enthusiast" and "Poor vehicle condition" (β=-0.14), this relationship is better explained via the "Adequate maintenance of vehicle". This conclusion is statistically justified by looking at the βs. Since β= -0.45 is a higher value (in absolute terms) than β= -0.14, we conclude that adequate maintenance has a stronger impact on a vehicle's condition than the activeness of the HV owner.

The practical information which can be gained from figure 20 is that there are some variables that determine activeness of an HV owner. If an owner is an active enthusiast then it is more likely that the owner better maintains his vehicle and it is less likely that vehicle is in poor condition. This sound logical and confirms intuition. In other words, the analyses show that our intuition is correct – we now have an underpinning for it.

In figure 20 we have added two new observed variables which need further explanation. On the right hand side of figure 20, there is a new variable called “number of nights spend outside home for events”. This variable is positively influenced if by the HV owner being an active enthusiast (β=-0.64), which means if a person is an active enthusiast then it is more likely that this person will participate in events and will stay away from home for HV events.

Another interesting variable added to figure 20 is called “km driven in 2013”. There is a negative (but small) influence from “poor vehicle condition” to this variable (β=-0.036). The interpretation is that as a vehicle’s condition is poorer, it is less likely that the vehicle is driven often. Again the results of statistical analysis confirm intuition.

## 4. Discussions and Conclusions

In this study we make use of several statistical techniques to analyse the survey data gathered by GfK on behalf of FIVA, from more than 19,000 HV enthusiasts in 15 member countries in EU. The aim is to investigate relationships between questions that were asked in the survey and conduct statistical analysis on the data. The outcomes of such analysis can be informative for FIVA and others and provide deeper insight from the HV owners and their characteristics, preferences and how they perceive the HV movement.

According to our data analysis we first reflect on the factors determining ownership and use of HVs. Our analysis in sections 3 and 4 show that five factors: living area, income, age, country and membership to clubs play important role on the three key criterions: ownership, expenditure and use of historic vehicles. Table 11 provides a holistic picture on significance (or non-significance) of these factors in connection with the criterions.

Table 13: Significance of 5 main factors on Ownership, expenditure and use of HVs

| | Ownership | Expenditure | Use |
|---|---|---|---|
| Country of origin | No | Yes | Yes |
| Level of income | No | Yes | Yes |
| Living area | Yes | No | No |
| Membership to clubs | Yes | Yes | Yes |
| Age of HV owner | No | Yes | No |

Key: (No) means no significant difference was found among enthusiasts with respect to the three criterions and (Yes) means there was a significant differences them.

There was no significant difference regarding the ownership of HVs among enthusiast from different countries that the survey was collected from. However, this is not true when it comes to expenditure and use of HVs. We saw that respondents from central European (e.g. Germany, Luxemburg, Austria) countries spend most on their HVs and also drive most. Respondents in Sothern and Eastern European countries spend the least but drive about as much as average.

Level of income did not have a significant difference on the HV ownership. Nevertheless, owners with higher income did spend and use HVs significantly more than low income owners (less than 15,000 euros per year). On average high income people (more than 175,000 euros per year) spent 4 times more on their total HVs than the lowest income people (with the exception of the highest income group [250,000 euros per year] which spent 9 times more on HVs than the lowest income group). Medium income owners (around 60,000 to 70,000 euros per year) spent 2 to 2.5 times more on HVs than low income people (see figure 11).

Regarding the use of HVs and level of income there was not a linear relationship. Low income and high income owners both used HVs more than average (13% and 29% respectively) and the medium income owners drove 2 to 3% less than average. Low income owners probably used HVs as a means of transport, not (only) for hobby reasons, and thus drove them frequently and high income people had multiple HVs and in total they drove more on their HVs than average.

HV ownership in congested and busy urban areas was significantly lower than in the quiet and uncongested rural areas, almost 30% lower. However, the use of HVs and expenditure on HVs do not significantly differ between various spatial living areas.

Membership of clubs proved to be an important factor in use, ownership and expenditure on HVs. Owners with 5 vehicles were on average members of 7 or more HV related clubs where as people with 2 HVs were members of on average 4 clubs. Please note that since many clubs were in charge of distributing the survey among enthusiast then the membership to clubs maybe inflated in our data set. Owners who were members of more clubs did spend more on HVs and also drove them more. However, this is perhaps due the fact that these owners possessed more HVs which in total increased their expenditure and their use.

The age of HV owners is only significant when it comes to the spending on vehicles. Middle-aged owners (between 53 to 70 years old) spend the most on their HVs with annual spending of more than 8500 euros in total. Whereas the youngest group of enthusiasts spend altogether around 4300 and the oldest group of owners spend no more than 3000 euros on their HVs.

Another important research question was to investigate the relationship between usage and the ownership of HVs. The relationship between usage and ownership showed that, when the HV enthusiast owns multiple vehicles the total mileage also increases. However, calculating on basis of individual vehicle, the mileage drops rapidly (to as low as one fifth) both in young and old timers (see figures 15 and 16).

The survey showed that most HVs can and do use common conventional fuels that are available in the market. In this respect fuels may hardly pose a serious problem to HV owners.

Although the impact of five main factors on expenditure was shown above, we would like to add that the age of the vehicle (at least for the cars in the survey) has significant impact on some aspects of expenditure (not all aspects). This relationship was investigated for cars only which represent the largest group of vehicles present in the survey. The average expenditure on non-fuel related costs (i.e. restoration, maintenance and car accessories) for cars made before 1940s was 35% higher than the overall average of 4020 euros per car per year. Expenditure of cars manufactured between 40s up to 70s were 7 % higher than average. These costs for cars manufactured after 70s were 17% lower than average.

We also tested the relationship between car age and its running costs, which included: insurance, garage rest, and road tax. From the three different categories of running costs only insurance costs was significantly different between different age groups of cars. For cars manufactured before 1940, the average insurance cost was 775 euros per car per year. This is 28% above average which is 565 euros per year per car. For cars manufactured between 40s and 60s the insurance costs was on average 610 euros per car per year, 8% higher than average. Finally the owners of cars made after 60s had to pay on average 523 euros per car per year, which is 8% below average.

From our data analysis we found out that mid-60s to mid-70s were the golden ages of old-timers with the highest number of HVs in the data set. Moreover, 60% of HVs were driven less than 2500 km in line with previous surveys conducted by FIVA (Frost & Hart, 2006) or other organisations such as FEHAC (2012).

As for the safety related questions that were asked, we saw that the accident rates (i.e. accidents that caused injuries per 100 million vehicle-kilometres) reported by all HV owners is 20% lower than UK accident rates (note that UK is one of the safest in EU).

Using latent class analysis, we determined five clusters of HV enthusiast and revealed some common behaviours and characteristics in each of these clusters. The labels these clusters are: Typical Enthusiasts, Old-School enthusiasts, Antiquarian, Regular Transport users, Collectors. The 'typical enthusiast' cluster is the largest and includes 69% of all respondents.

Finally by using SEM, we showed how activeness of HV enthusiasts and the quality of vehicle maintenance can be measured via relevant parameters that are currently present in the data set. We determined how these concepts influence the condition of HVs. These findings are intuitively rational but we use data and statistical methods to prove the claimed concepts.

## Future Study

Above we present a selection of advanced statistical analyses of the data. We based our selection on relevance for FIVA, the wider HV community and policy makers.

The collected data set is rich enough to conduct more studies. We propose further research to be done regarding the difference in behaviour and characteristics of passenger car owners and other vehicle categories (e.g. motorbikes, mopeds, vans, tractors). Due to presence of numerous vehicle types in the data set, we were not able to repeat different statistical analysis methods for each vehicle type other than passenger cars. Moreover, one can study the spending behaviour of HV owners based on certain popular brands with consideration of demographic information.

We aim to publish the outcomes of this study in academic journals. Based on the review comments it is possible we modify our analyses.

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# Appendix A: Technical description of methods used in this study

In the part2 of the report we have conducted advanced statistical analysis on the data supplied by FIVA from the survey conducted from HV owners in 15 EU countries. For those interested readers, in this appendix, we briefly mention those statistical techniques that were used in our analysis.

When relations between observable and non-observable (latent) variables and a dependent variable are found, it is usual to see if this relationship is statistically significant. Common techniques used to do this are "One way ANOVA" tests and "multivariate data analysis". One way ANOVA test is a popular test to investigate trends and also to look for average behaviour of a variable among different groups of respondents that are categorized based on certain assumption. Multivariate regression is another widely used method to establish relations between observed variables and a dependent variable. This relationship can either be linear or curvilinear depending on how it best fits to the data provided. This kind of regressions enables one to gain some predicting power based on the data and derive some important interpretations.

In this study we applied two more advanced techniques: latent class analysis (LCA) and structure equation modelling (SEM). Latent class analysis (LCA) is applied to explore latent clusters among respondents of the survey and to reveal heterogeneity among them and to investigate common preferences and patterns of homogenous clusters of respondents. Structure equation modelling (SEM) is applied to conduct confirmatory analysis on causal relations between different concepts, or latent variables in the model. SEM models sometimes provide results which could not have been obtained by regular data analysis methods.

# Appendix B: How many jobs do historical vehicles generate? A rough estimate[8]

## B.1. Introduction

FIVA is interested in an estimate of the number of jobs related to historical vehicles. We define HVs as vehicles over 30 years old.

The number of jobs depend on:

- The number of historical vehicles (HVs) or the number of owners of HVs
- The expenses per HV or per owner of HV
- The amount of money related to one job

Below we provide estimates for each factor and next come to an estimate of the number of jobs. We use results of the GfK research and other inputs to come to our estimates.

For an estimate of the number of jobs in the EU two additional factors matters: (1) the share of EU jobs, in the total number of jobs generate (not all jobs generated by HVs have to be EU jobs), and (2) the number of jobs due to expenditures of HV owners in non EU-countries, in EU countries. We discuss these topics below.

## B.2. Assumptions

- We assume average GfK results to apply for all EU countries.
- We exclude insurance costs because including these could easily lead to double counting. This because a substantial share of the insurance costs will be used to cover expenses made on HVs, and these expenses are already included in our estimates. If, for example, a person has an accident and the related repair costs are, say 10,000 euro, but the insurance pays for it, including insurance costs would lead to double counting, and therefore should not be included. This assumption results in an underestimation of the number of jobs because insurances generally make profits and generate jobs.
- Taxes are not included because these are transfers from owners to governments which do not generate additional jobs.
- We excluded fuel costs, firstly because crude oil is mainly imported from outside the EU and therefore does not generate jobs in the EU (though refineries and distribution of fuels do generate jobs) and secondly because an unknown share of kilometers driven by HVs would have been driven by regular vehicles would their owners not have HVs.

All in all our estimate for expenditures is a low estimate.

## B.3. The number of vehicles / owners

The questions on expenditures of GfK were answered per owner, not per vehicle.

[8] We thank Prof. Dr. Carl Koopmans (Free University Amsterdam and Amsterdam University) for his comments on a draft version of this document.

By the end of 2013 the EU28 had 507 million inhabitants (http://www.europa-nu.nl/id/vh6tqk1kv3pv/europese_unie_in_cijfers).

In 2009 people in Europe (EU-27) owned around 473 cars per 1000 inhabitants (http://en.wikipedia.org/wiki/Motor_vehicle). So there are around 239 million cars in the EU. Based on several sources we assume 1% of the active car fleets to be HVs. Then there are around 2.4 million historical cars. Note that in addition there is an unknown number of 'passive' vehicles. In the GfK database this number is 6%, but this likely is an underestimation – probably there is bias towards active vehicles. Probably this is no problem, firstly because questions on expenditures relate to owners, not vehicles, and secondly because potential bias because of an underrepresentation of owners who only have passive vehicles is not relevant if we assume those people do not or hardly spend any money on these vehicles.

GfK results that cars are by far the most important vehicle category, followed by motorcycles. According to GfK data there are 40% more HVs than cars only. So there are around 3.35 million HVs. The average owner of HVs has 2.2 vehicles (GfK). So there are around **1.5 million HV owners.**

## B.4. Expenses

GfK results give next figures per HV owner:

| | |
|---|---|
| Restoration costs | 2335 |
| Maintenance and repairs | 840 |
| Accessories | 607 |
| TOTAL | 3782 |

Note that these costs are lower than the total expenses on historical vehicles of on average 6,500 euro (GfK-result) because we exclude purchasing vehicles, taxes and fuels. Some of the expenses are related to HV owners buying parts from other HV owners. Such expenses do not or hardly generate jobs. It is unknown how large the share is but we estimate this to be a small proportion. We did not correct for this factor. In addition, it is possible that HV owners spend more on their vehicles than all owners of vehicles over 30 years old, and HV owners probably are overrepresented in the GfK study. Again we did not correct for this factor.

To conclude we assume jobs related expenses to be 3782 euro per owner. Multiplying this figure by 1.5 million HV owners total expenses are around 5.7 billion euro.

## B.5. Jobs per euro

To the best of our knowledge there are no figures for the number of jobs per million euro. We assume a value of 50,000. Note that most jobs related to HVs are probably related to restoration, repairs, maintenance, and production (of parts). These jobs are probably paid lower than average.

## B.6. Correction for within/outside EU

We only have date for service costs. The GfK results reveal that 98% of all service costs were made within the EU. We assume the expenditures made outside the EU are of the same order of magnitude as the expenditures of non EU-residents did in EU countries. Therefore we assume all expenditures as presented above are related to EU jobs.

## B.7. Expenditures in hotels

HV owners in the GKF study spent 16185 nights in hotels, about 0.83 night per owner . Assuming 50-75 euro per night and assuming that these respondents are representative for all HV owners, at the EU level there are 1200000 nights spent in hotels, for 60 to 90 million euro. Assuming again the value if 50,000 euro per job another 1200 to 1800 jobs are generated.

## B.8. Number of jobs and interpretation

Assuming total expenses to be 5.7 billion euro and the value of 50,000 euro per jobs we estimate the number of jobs to be around 110,000 jobs. Note that this is low estimate, as explained above, and the estimate is based on several assumptions. A more general estimate is that the number of jobs probably is around **100,000 to 140,000.**

What does this mean? This is 'only' an estimate of the number of jobs related to HVs. This does not mean that if all HVs should be exported to outside the EU this amount of jobs will get lost, certainly not on the long run. People will then spend their money on other goods and services, which generate jobs, though not necessarily for the same people who now have a job related to HVs. Depending on how they will spend their money (mainly: which part will be spend on goods and services that are produced outside the EU) the decrease in the number of jobs will be lower, up to zero.