Household behaviour and environmental policy

Report on transport related data analysis

OECD Project on household behaviour and environmental policy

Household behaviour and environmental policy Report on transport related data analysis

Claude Weis

Kay W. Axhausen

Arbeitsberichte Verkehrs- und Raumplanung **705**

March 2012

Institut für Verkehrsplanung und Transportsysteme
Institute for Transport Planning and Systems

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Acknowledgements

The authors would like to thank the partners at OCED for the opportunity to analyse the very rich data set from their household survey and for the productive cooperation during the project.

Table of contents

Tables

Figures

Household behaviour and environmental policy

Report on data analysis

Claude Weis
IVT, ETH Zurich
CH-8093 Zurich

Phone: +41 (0)44 633 39 52
Fax: +41 (0)44 633 10 57
weis@ivt.baug.ethz.ch

Kay W. Axhausen
IVT, ETH Zurich
CH-8093 Zurich

Phone: +41 (0)44 633 39 43
Fax: +41 (0)44 633 10 57
axhausen@ivt.baug.ethz.ch

March 2012

Abstract

The project on household behaviour and environmental policy initiated by the Environment Directorate of OECD intends to improve the understanding of the determinants of environment-related household behaviour and households' responses to environmental policies. This work aims at providing guidance to policy-makers for the design of efficient and effective environmental policies targeted at households in five areas – residential energy and water use, transport choices, organic food consumption, and waste generation and recycling.

The OECD conducted a large scale household survey on environmental behaviour in 2011 in eleven countries representing different regions: Australia, Canada, Chile, France, Israel, Japan, Korea, the Netherlands, Spain, Sweden and Switzerland.

The Institute for Transport Planning and Systems (IVT) at ETH Zurich was contracted to carry out a descriptive analysis on the data resulting from the abovementioned survey, in the context of travel behaviour.

Keywords

OECD household survey; transport choices; travel behaviour

Preferred citation style

Weis, C. and K.W. Axhausen (2011) Household behaviour and environmental policy – Report on transport related data analysis, *final report*, OECD, Paris.

1 Background

Environmental pressures from households are significant, and their impacts are likely to intensify over the coming years. As governments introduce a variety of measures to encourage greener practices, influencing behaviour remains a challenge. The project on Household Behaviour and Environmental Policy (www.oecd.org/environment/households) initiated by the Environment Directorate of the Organisation for Economic Co-operation and Development (OECD) intends to improve the understanding of the determinants of environment-related household behaviour and households' responses to environmental policies. This work aims at providing guidance to policy-makers for the design of efficient and effective environmental policies targeted at households in five areas: residential energy and water use, transport choices, organic food consumption, and waste generation and recycling.

This work involves the implementation of a series of large scale OECD household surveys on environmental behaviour. A first survey was implemented in 2008 in ten countries and the main results are presented in OECD (2011). A new round of the survey was implemented in 2011 in eleven countries representing different regions: Australia, Canada, Chile, France, Israel, Japan, Korea, the Netherlands, Spain, Sweden and Switzerland.

This new round covers the same five thematic areas. Based upon the analysis of the data collected, practical policy recommendations will be formulated to design efficient and effective environmental policies targeted at households.

This OECD activity intends to widen the scope of previous analysis in a number of ways, in particular by:

- Bringing together key aspects necessary to understand household behaviour: responses to environmental policy instruments implemented to affect household behaviour, role of socio-demographic characteristics (e.g. income, age, education levels, household size) and of more attitudinal variables (e.g. environmental concerns, norms and values).
- Examining the effect on households of a broad range of environmental policy instruments in the five areas examined. Measures to be examined for policy guidance include economic instruments (e.g. unit-based fees vs. flat fees for waste, energy taxes, congestion charging), information-based instruments (e.g. energy efficiency labels, organic food labelling), direct regulation (e.g. parking restrictions, efficiency standards) and the provision of public services (e.g. drop-off vs. collect recycling schemes, quality of public transport).

- Considering the contributions of economic theory (welfare economics, behavioural economics, etc.) as well as different disciplines such as psychology and sociology, which complement each other to provide a more comprehensive picture of household behaviour and response to environmental policies.
- Developing policy implications for the design and implementation of environmental policies targeted at households, drawing from the review of existing evidence available in selected OECD countries as well as the development of a unique international comparative analysis across the five key environmental issues addressed.

The activity for 2011-2012 consists of three main phases, the first of which has already been undertaken.

- Phase 1 – Finalisation on the questionnaire drawing on the experience of the first survey in the same five policy areas (energy, waste, food, water and personal transport) and implementation of the second round of the OECD household survey on environmental behaviour covering 11 OECD countries representing the three OECD regions (North America, Europe and Asia-Pacific): Australia, Canada, Chile, France, Israel, Japan, Korea, the Netherlands, Spain, Sweden and Switzerland. Sample of approximately 1000 for each participating country and implementation of the survey using a web-based access panel.
- Phase 2 – Descriptive analysis of the survey data by research teams coordinated by the OECD Secretariat. This will focus on differences in environmental behaviour across countries, policy contexts, demographics, and socio-economic characteristics. Comparison with evidence from related studies will be undertaken. Preparation of thematic reports by research teams based upon the review of the data (2011).
- Phase 3 – More formal empirical analysis of the determinants of household environmental behaviour based upon the development of appropriate models of household behaviour and econometric methodologies and development of policy recommendations drawing upon the results of empirical analysis. Presentation of the results of the empirical analysis and publication of the main conclusions and policy implications (2012/2013).

This report deals with the work undertaken in Phase 2, in the area of transport choices.

2 Objectives

Using the survey data, a descriptive analysis of personal transport was undertaken. The tasks involved the presentation of the data across countries, demographics, socio-economic characteristics and policy contexts. In particular, the effects of the following variables were to be reviewed:

- economic (income levels, education, job status, etc.), demographic (household size and composition, age, urban/rural, etc. and other variables (e.g. type of residence);
- attitudinal characteristics (values, perception on environmental concerns, member of environmental NGO etc.) – a set of indices describing these attitudes was developed.

In addition, the effects of different policy variables targeting household car use was to be emphasised (e.g. fuel tax, congestion charges, financial support to purchase alternative-fuelled vehicles, availability of public transport and quality of public services).

Some of the principal issues related to the role of policy contexts, which were to be assessed in the review of the data include the following:

- How do attitudes towards the environment correlate with mode choices and public transport use?
- How do attitudes towards the environment correlate with car ownership, car use and car choice?
- How is household car ownership and car use influenced by the presence of adequate public transport options?
- What characteristics of public transport are most important in encouraging households to switch from car use?
- How important are environmental considerations in car choice?
- Who benefits most from improvements in public transport services? Who is most reluctant to switch from car use?
- What affects preferences for alternative government actions to reduce motor vehicle CO_2 emissions?
- How effective is car labelling? For which type of household?
- How much are households willing to pay as a price premium to purchase an electric car? Does the willingness-to-pay (WTP) vary significantly across household groups?

3 Literature overview

OECD (2011) provides a broad overview of the existing literature on the influence of certain personal characteristics on travel behaviour, particularly in terms of car ownership and use. Both those variables are closely related, and appear to be influenced in similar ways by persons' and households' attributes. In the example studies from The United States and Europe that are reviewed in OECD (2011), both car ownership and use are positively influenced by income and household size. The results on the influence of age are ambiguous; the effects of age on travel behaviour can however be expected to be non-linear (that is, fluctuating for different life phases; see for example Weis and Axhausen, 2009, for a model of the effects on general activity participation). Thus, they need to be carefully analysed in the context of each study before making statement about general trends.

Accessibility to public transport has a negative effect on car ownership and use, although this effect has only been examined in a few select studies from Austria (Simma and Axhausen, 2004), the United Kingdom (Dargay and Hanly, 2004; Giuliano and Dargay, 2006) and the United States (Giuliano and Dargay, 2006). In the context of the 2008 OECD household survey conducted in 10 participating countries, the same effect on car ownership was found, while the effect of public transport accessibility on car use was surprisingly positive. The same survey data provided indications that awareness towards environmental issues in general tend to lower persons' car use. Variables describing those attitudes are of particular interest here as well, and will be studied in as much detail as necessary to assess the corresponding trends.

In a recent study in the Swiss context that was conducted by the authors (Weis *et al.*, 2010), similar effects with regards to the influence of socio-economic characteristics, and particularly the quality of the public transport supply, on mode choice were observed. Furthermore, parking policies hold a large potential in determining persons' mode choice decisions (Weis *et al.*, 2011). These can however not be examined in detail here, as the data set lacks the coverage of any corresponding variables; the same holds for the certainly important influence of prices (fuel costs, public transport ticket fees, road tolls). Here, only attitudes towards corresponding policies can be examined, as opposed to measured effects of different pricing schemes in the various participating countries.

4 Classification of respondents

4.1 Activity levels

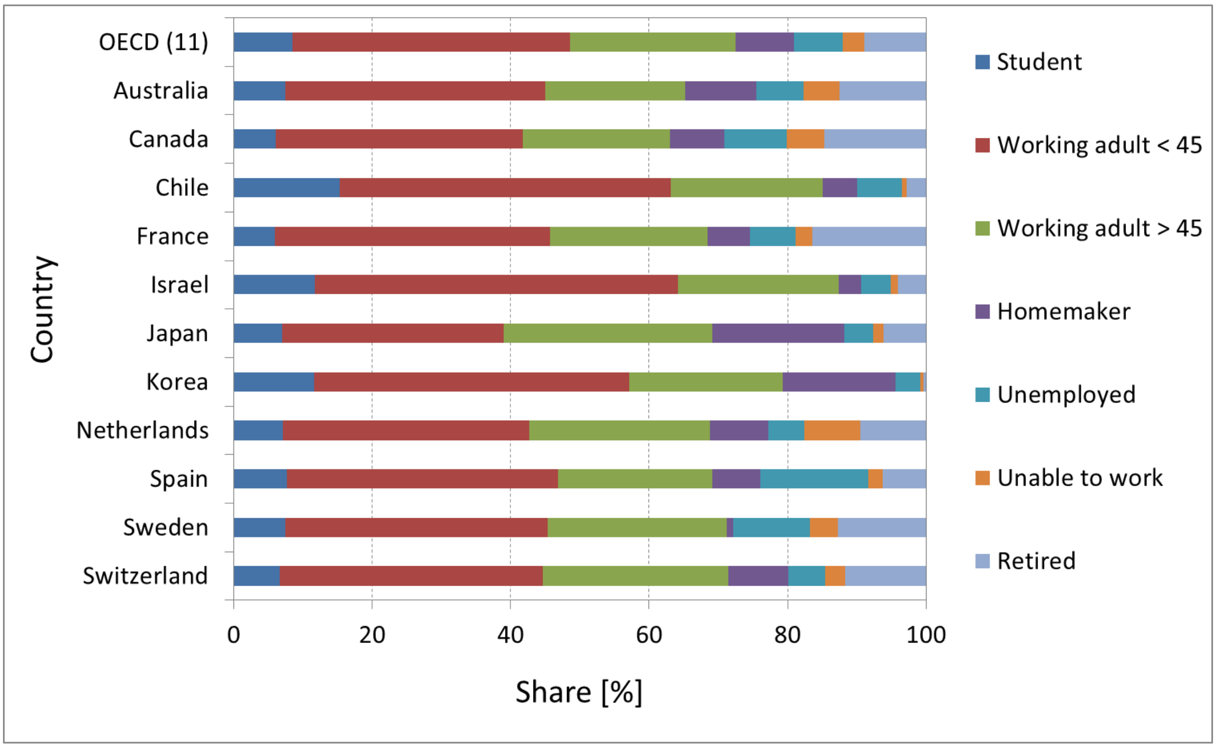
In order to simplify the number of analysis levels, and to obtain a good indication of the interaction of some effects, the participants in the survey were aggregated into the following activity levels (and sub-categories, where needed), based on their age and employment status:

- students (in education and under 30 years old);
- working adults (1 – working and under 45 years old / 2 – working and over 45 years old);
- non-working adults: homemakers, unemployed, or unable to work (under 60 years old);

(1)retired (not working and over 60 years old).

Figure 1 shows the distribution of the activity level categories over the respondent sample. The largest share of respondents are working adults, who can be expected to contribute significantly to overall travel demand.

Figure 1 Distribution of activity levels, by country



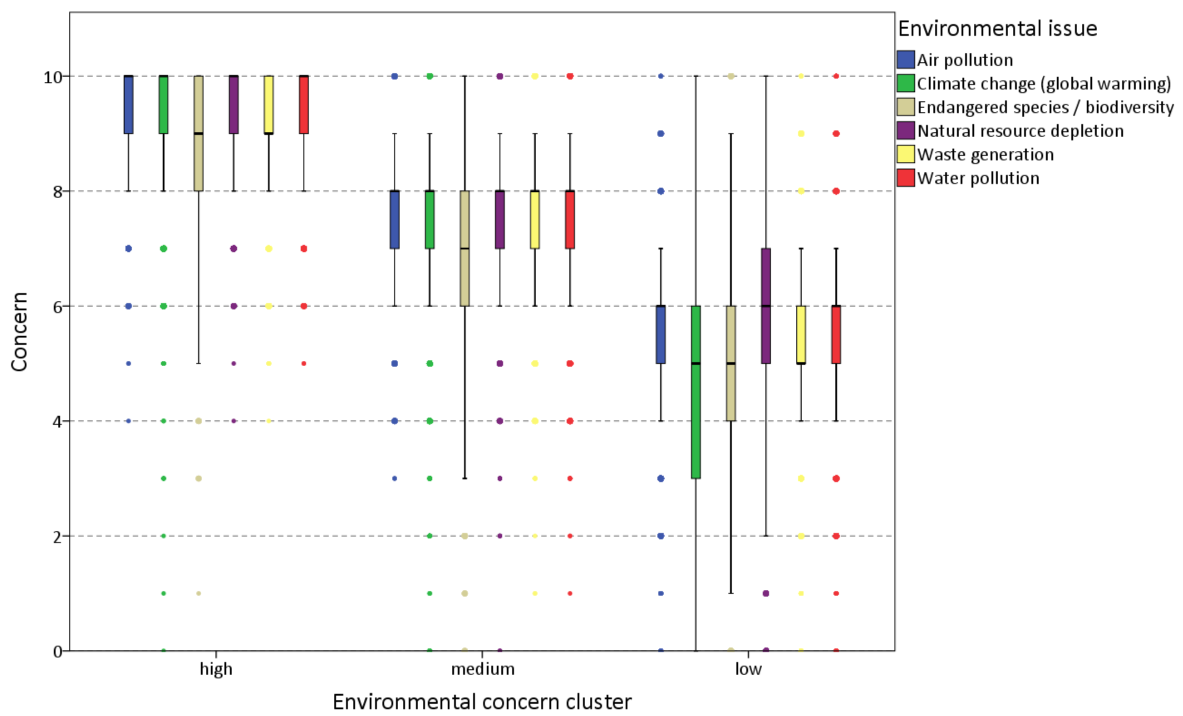
4.2 Environmental concern and attitude clusters

To represent the respondents' overall degree of environmental concern, a cluster analysis was carried out. The respondents were classified in one of three categories (the number of categories being chosen by the algorithm carrying out the classification), based on their answers to questions (on a 1 to 10 scale) on how serious they thought the following issues facing the world were: waste generation; air pollution; climate change (global warming); water pollution; natural resource depletion (forest, water, energy); and endangered species and biodiversity.

Figure 2 shows boxplots of those scale variables for each of the three newly formed clusters. As can be seen, members of one cluster exhibit roughly the same average concern for all the indicator variables. In all clusters, the variation in valuation is greatest for the concern about biodiversity.

The environmental concern clusters will be used as a unifying variable in subsequent analyses of the effects of environmental attitudes on travel behaviour. The cluster membership will be used as a proxy for the indices in the analyses that are presented here; it has the advantage of being able to present averages or distributions for the various classes and thus give an indication of the impacts of the respondents' environmental concern on travel behaviour.

Figure 2 Importance of environmental issues, by environmental concern cluster



Additionally to the questions on environmental concerns presented above, the respondents were asked how strongly they agreed with a series of statements, namely:

(1) I am not willing to do anything about the environment if others don't do the same.

(2) Environmental impacts are frequently overstated.

(3) Environmental issues should be dealt with primarily by future generations.

(4) I am willing to make compromises in my current lifestyle for the benefit of the environment.

(5) Policies introduced by the government to address environmental issues should not cost me extra money.

(6) Environmental issues will be resolved in any case through technological progress.

(7) Protecting the environment is a means of stimulating economic growth.

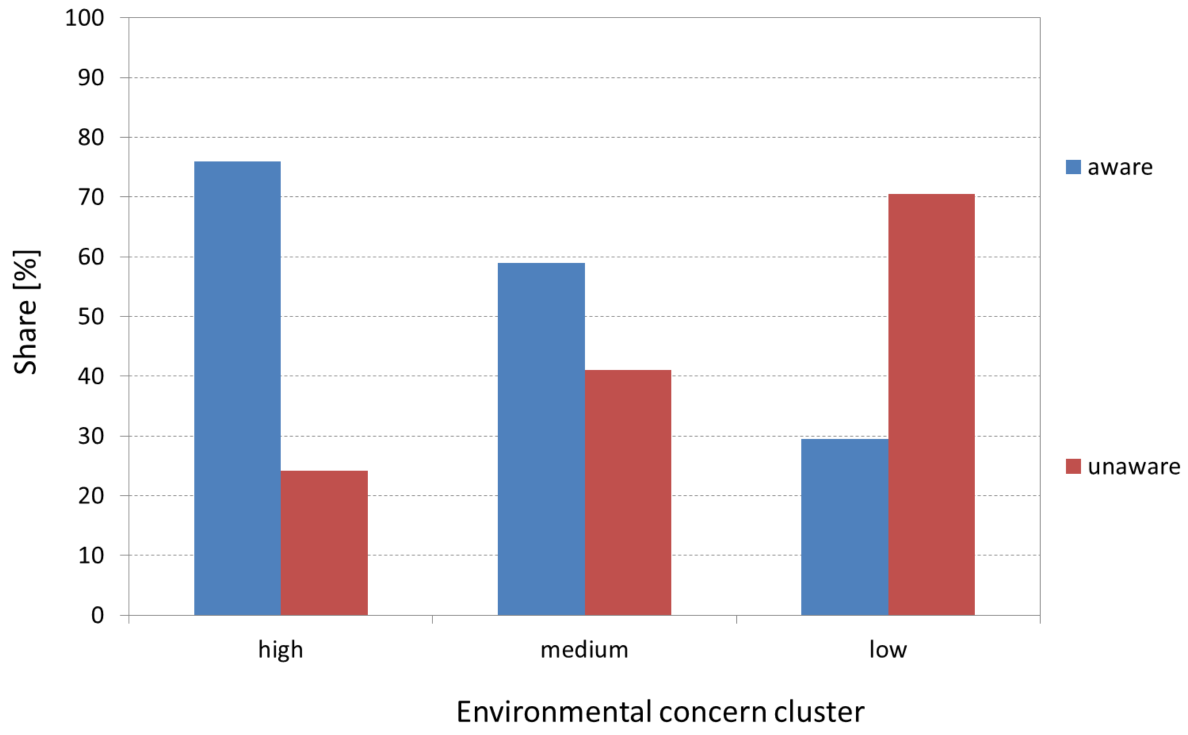
A second cluster classification was performed based on the respondents' assessments of these questions. The automatic clustering algorithm led to two clusters being created, which will be referred to as environmentally "aware" and "unaware", respectively.

As Figure 3 shows, membership to the various clusters of the two categorisations is closely related – respondents who are highly concerned with the environment also tend to agree more on statements pointing at a strong willingness to commit to environmental protection, and vice-versa. It is thus to be expected that any effects of the two clustering variables would also be confounded or at least close to each other.

In that vein, only where significant differences were found in trends between the two clustering variables constructed here, analyses based on both those variables will be presented in the subsequent sections of this report. Otherwise, where only one general trend could be observed (that is, where the effects of high environmental concern and strong awareness are confounded), only the analyses based on the first clustering variable will be shown. In cases where the effects of single components of the clusters (that is, of concerns with or attitudes towards a specific issue) seemed to be of interest, these effects are pointed out separately.

Another possibility to account for the confounding effects would have been to include all of the questions on environmental concerns and attitudes in one single clustering variable; this led to practically the same result as the clustering by environmental concerns by itself, which indicates that the corresponding variables appear to have a stronger influence on cluster membership than those on attitudes.

Figure 3 Environmental attitude clusters, by environmental concern cluster



5 Car ownership

This section provides a first analysis of the respondents' travel behaviour. Car ownership should provide a general indication of the impacts of the respondents' travel.

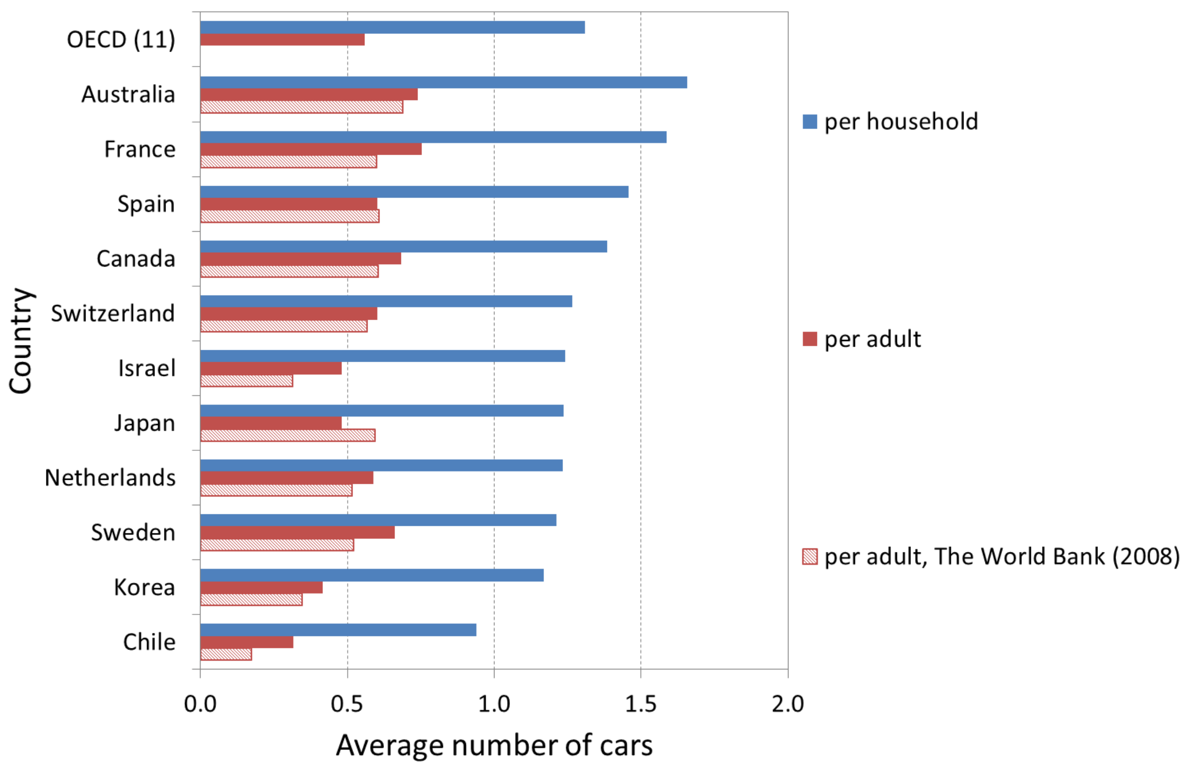
5.1 Ownership rates by country

Figure 4 shows the average values for the number of cars owned per household and per adult person in the 11 participating countries, as well as in the whole sample.

Car ownership rates are among the highest in Australia and Canada, where distances are traditionally long, and the car often the only viable option for covering those distances. The lowest car ownership rates are reported in Chile, Korea and Sweden.

The overall average car ownership rate for the respondent sample is 1.31 cars per household, respectively 0.56 cars per adult person. The rates given by The World Bank (2008) are shown for comparison; overall, the ownership rates in the sample are thus slightly over-estimated.

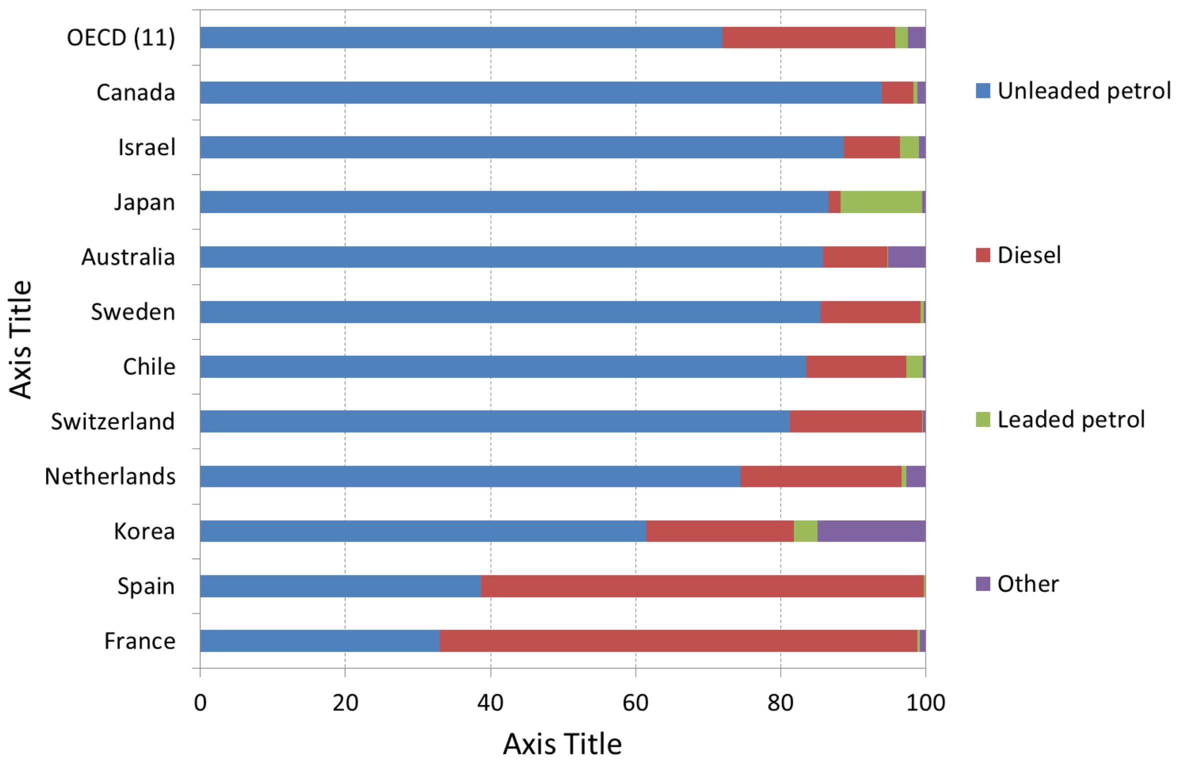
Figure 4 Car ownership, by country



5.2 Fuel types

Vast differences exist between the 11 countries as far as the fuel type of the main vehicle owned by the respondents' households is concerned. As Figure 5 shows, France and Spain rely heavily on diesel cars, while most other countries have a large majority of unleaded petrol cars. The share of alternative fuels (electric, hybrid, and particularly bio-combustibles) is largest in Korea.

Figure 5 Distribution of fuel types of main vehicle, by country

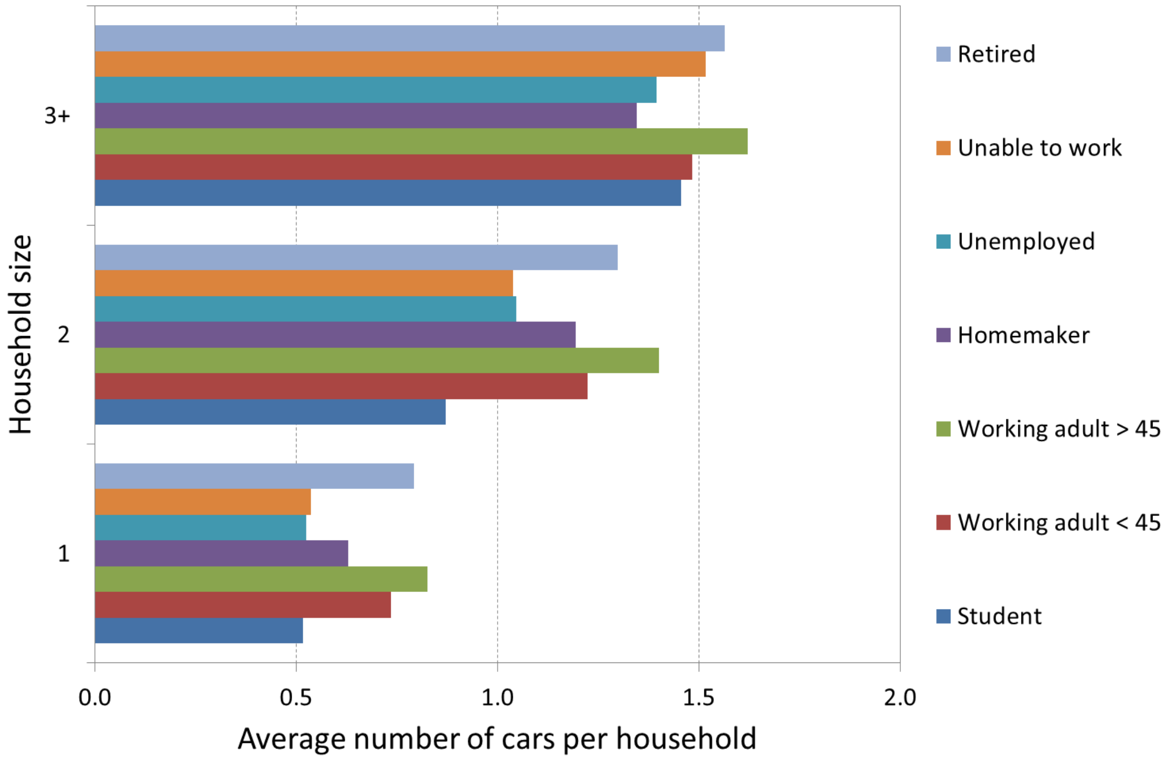


5.3 Impact of socio-economic characteristics

A number of socio-economic characteristics was expected to influence the decision to own a car: household structure, age, gender, income, job type, etc. The joint influences of all of these variables on car ownership (and other indicators) can only be assessed in a multiple linear regression (or structural equations) model.

To exemplify the effects in the context of the present descriptive analysis, the interaction between activity level and household size is shown in Figure 6.

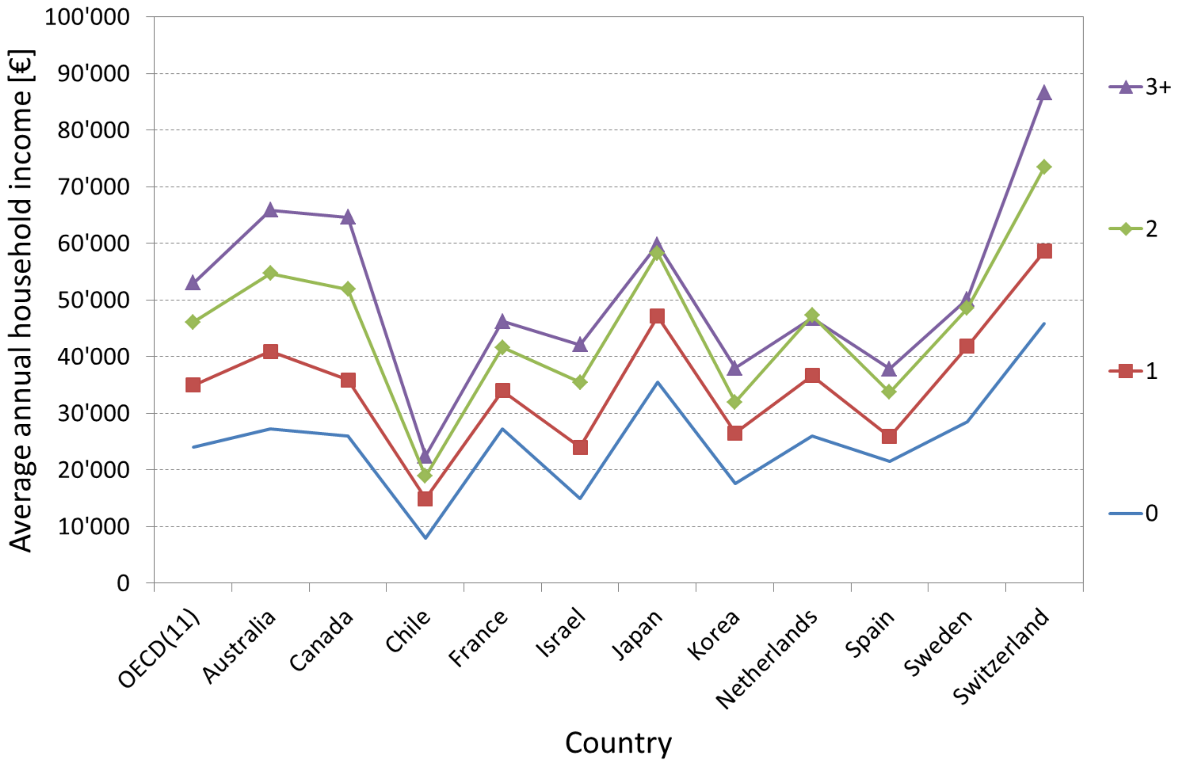
Figure 6 Car ownership, by activity level and household size



The separate effect of both variables on car ownership is evident. There are more cars in larger households, and in households of working adults. However, in single person households, where car ownership is determined by the respondent alone, the latter pattern is the clearest. On the other hand, unemployed respondents' households have almost the same car ownership rate as those of working adults, when the households are large. This is probably due to other persons in those households being employed themselves, and owning cars. These interaction effects will have to be taken into account when estimating models of car ownership with the data.

Figure 7 shows that the average household income is consistently higher the more cars a household owns. This holds for all 11 participating countries, with the expected fluctuations due to general income differences between the countries. Overall, households owning one car dispose of about 50 per cent more income, and households owning two cars possess about double the income, of households owning no cars.

Figure 7 Household income, by car ownership rate



5.4 Factors influencing car choice

On a 1 to 10 scale, the respondents were asked how important various factors were in determining their car choice. As Figure 8 shows, safety appears to be the most important factor in all but very few countries, closely followed (and, in Canada, Sweden, Australia and France, surpassed) by price and reliability. The least important factors are brand affinity and environmental concerns. When considering the analysis by the environmental concern clusters described above, it becomes obvious that individuals highly concerned with environmental issues also place a higher emphasis on environmental impacts when choosing their cars. Interestingly though, the relative valuation of the indicator when compared to the others is quite low even for these respondents (Figure 9).

Figure 8 Importance of factors influencing car choice, by country

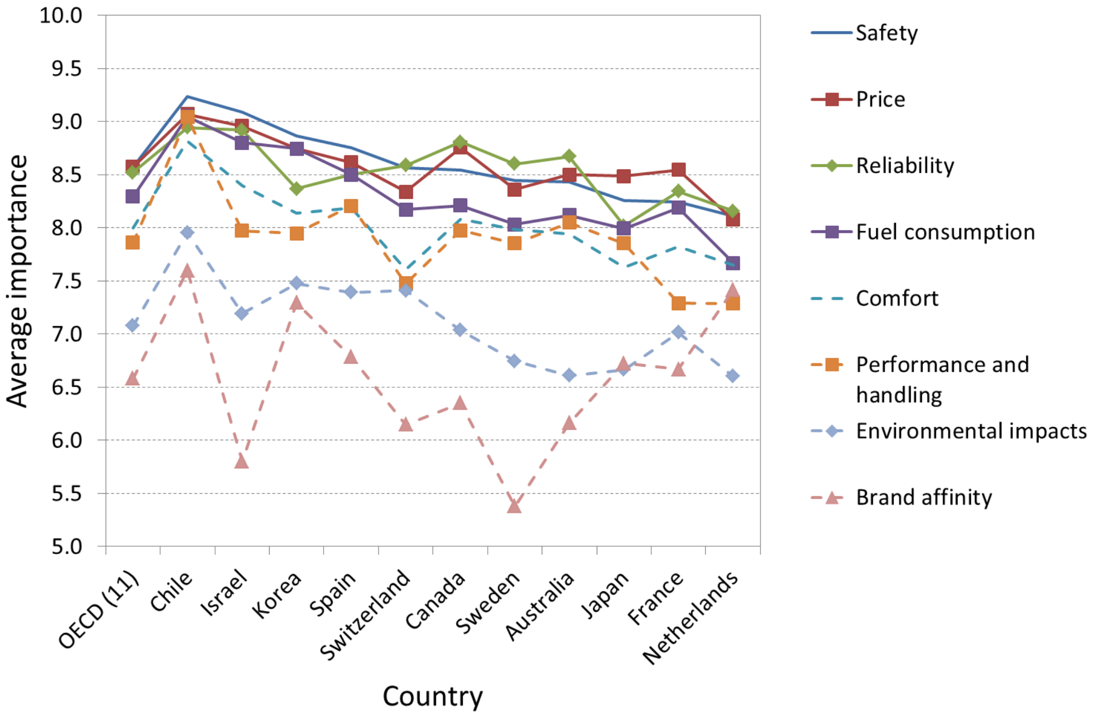
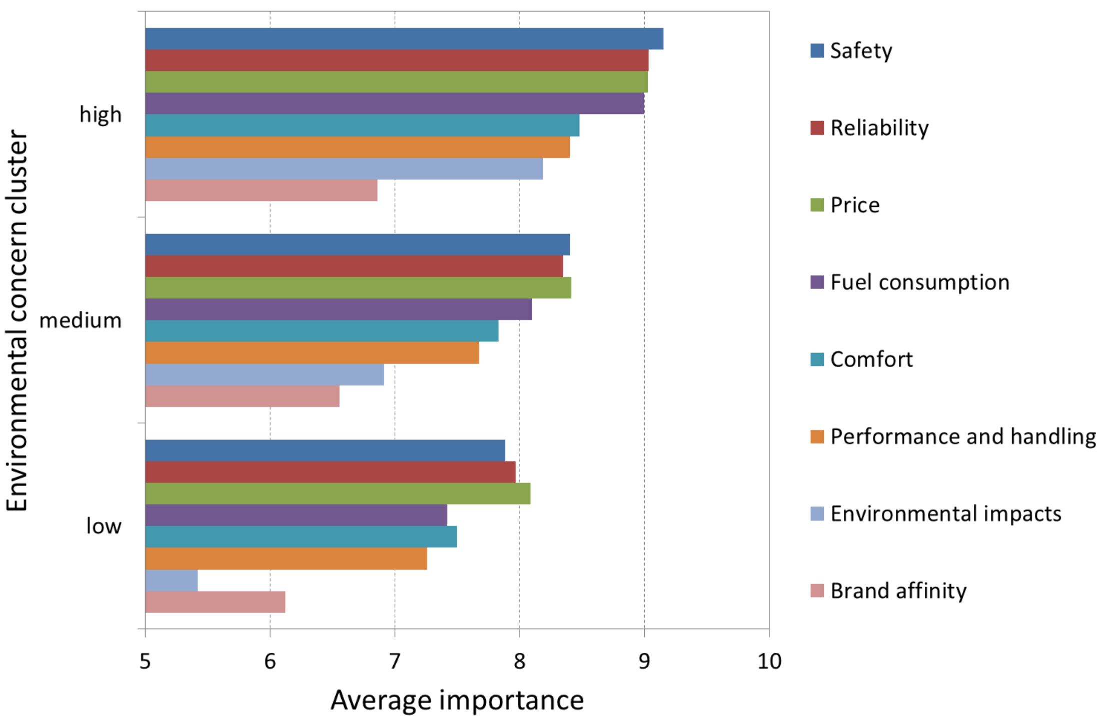


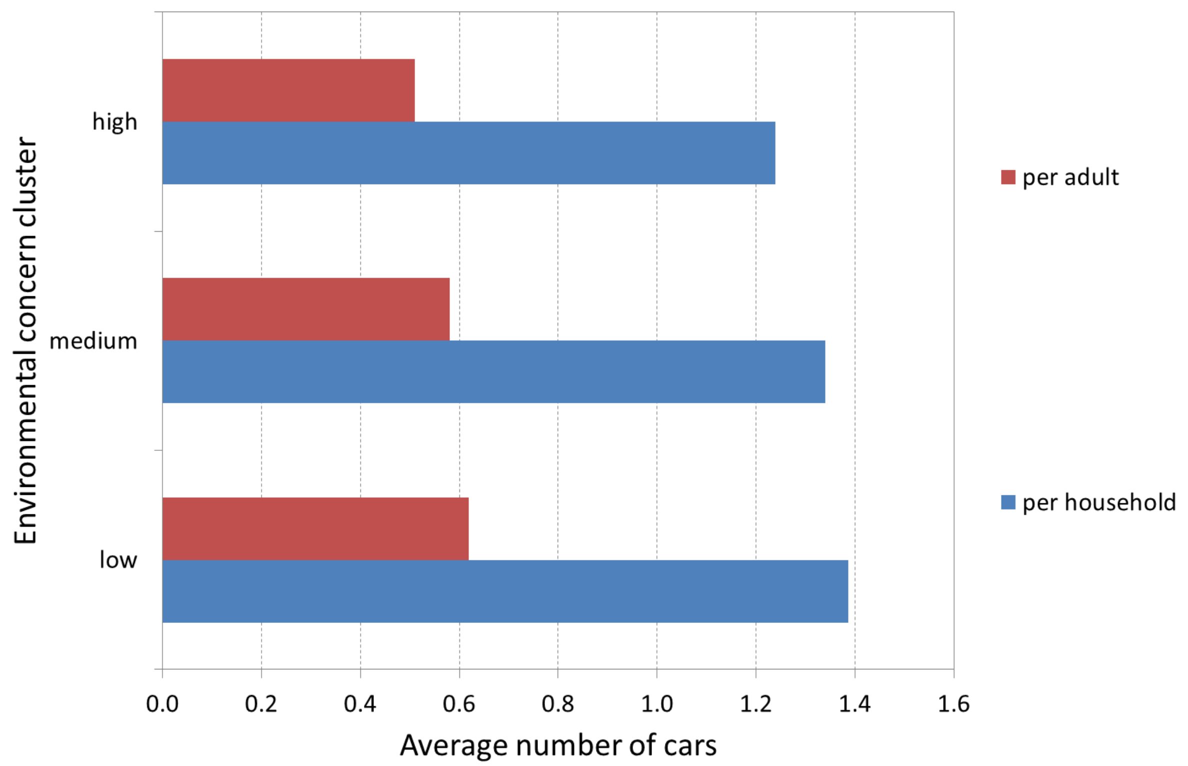
Figure 9 Importance of factors influencing car choice, by environmental concern



5.5 Impact of environmental concern and spatial characteristics

Environmental concern as represented by the clusters has a non-negligible effect on car ownership, as can be seen in Figure 10. Respondents belonging to the "high" environmental concern cluster own around 20 per cent less cars per adult than those from the "low" cluster.

Figure 10 Car ownership, by environmental concern cluster



The impact that environmental concern has on car ownership raises the question of residential self-selection, that is the choice of a neighbourhood based on behavioural preferences (Mokhtarian, 2008; Cao *et al.*, 2009). It may be expected that individuals who are highly concerned by environmental issues would choose to live in urban areas with good public transport access and dense neighbourhoods where shopping and leisure opportunities are located within close distances (and thus do not have to be reached by car). As Figure 11 shows, this is indeed the case for the respondent sample – the share of urban population is about 20 per cent higher in the "high" than in the "low" environmental concern cluster. The abovementioned interaction effect is also evidenced by Figure 12. Across environmental concern clusters, car ownership is considerably lower in urban areas than elsewhere, and vice-versa. It can be concluded that for at least a part of the respondent sample, there is a reciprocal effect of desired mobility patterns on residential location. The exact nature of the causal relationship of these effects may be determined by a structural equations model (Bagley and Mokhtarian, 2002).

Figure 11 Area type of residential location, by environmental concern cluster

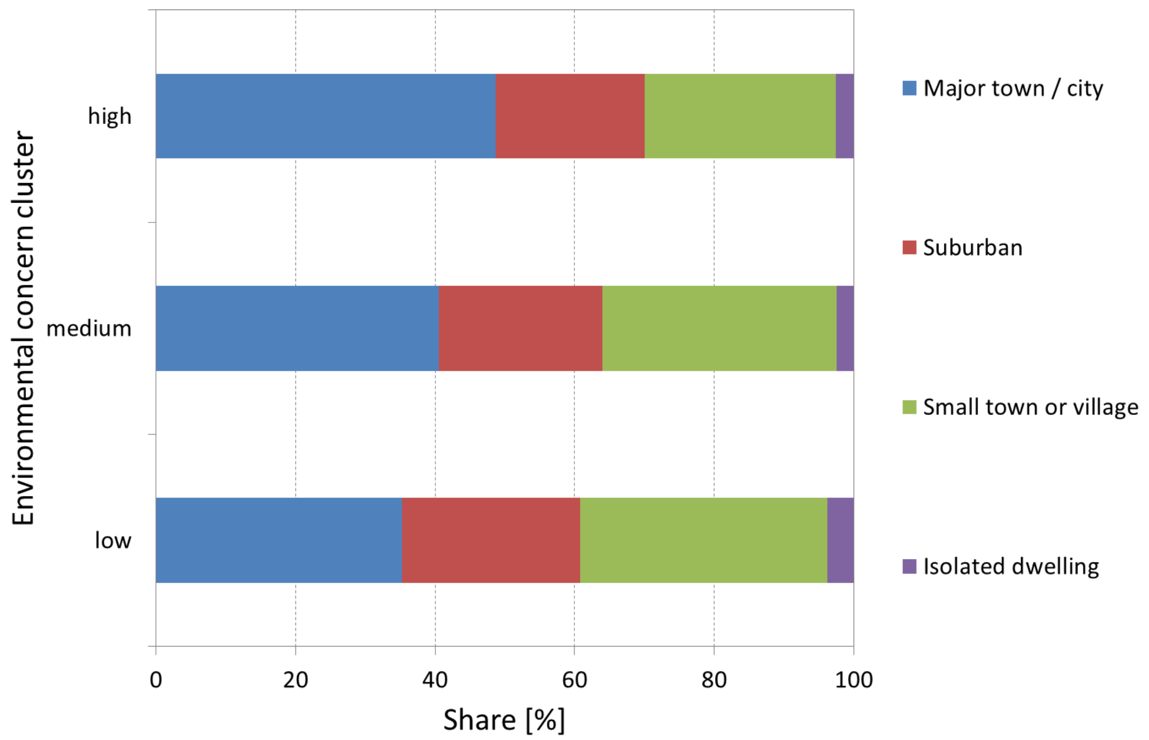
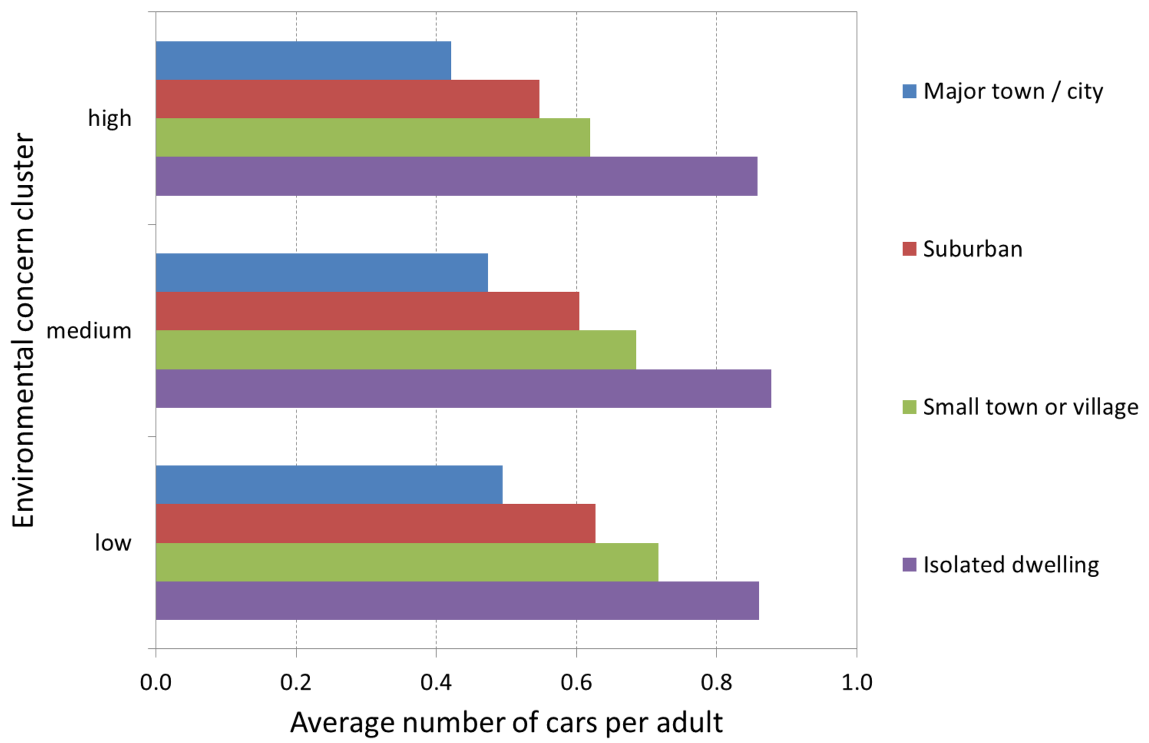
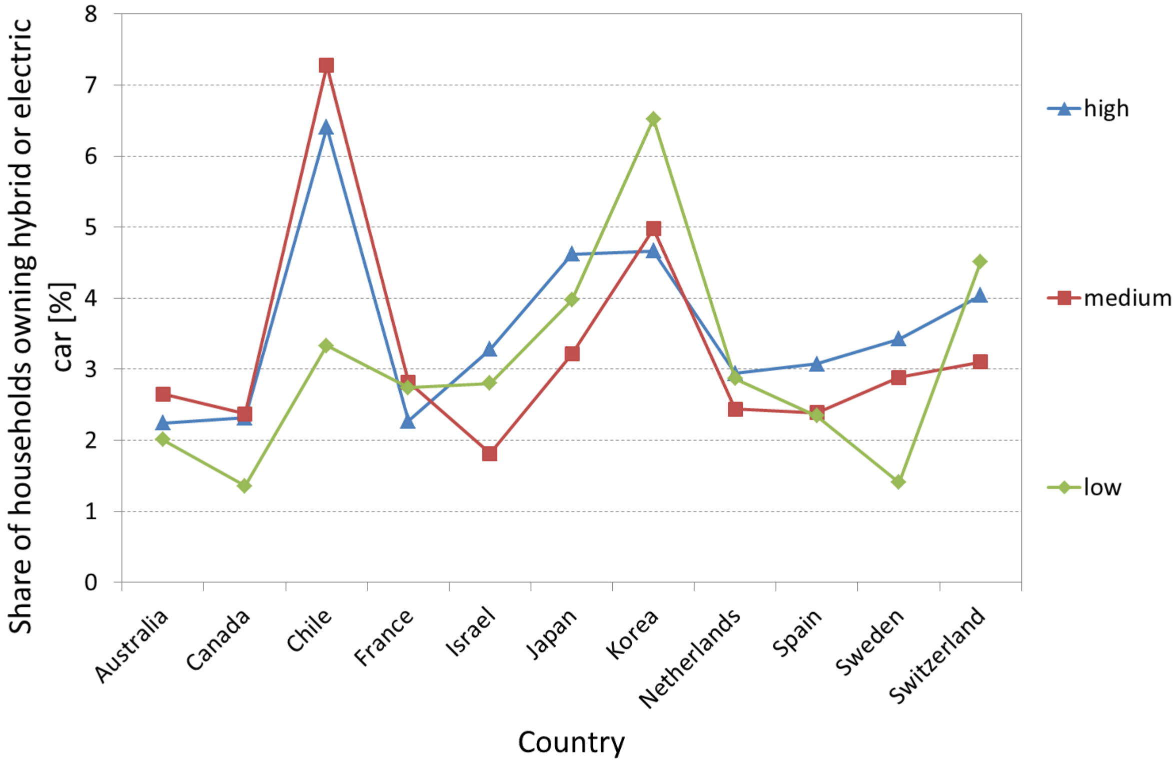


Figure 12 Car ownership, by environmental concern cluster and area type



In addition to the number of cars owned, the choice of a fuel type is influenced by environmental attitudes. As Figure 13 shows, there is no clear-cut trend exhibited by the clustering variable.

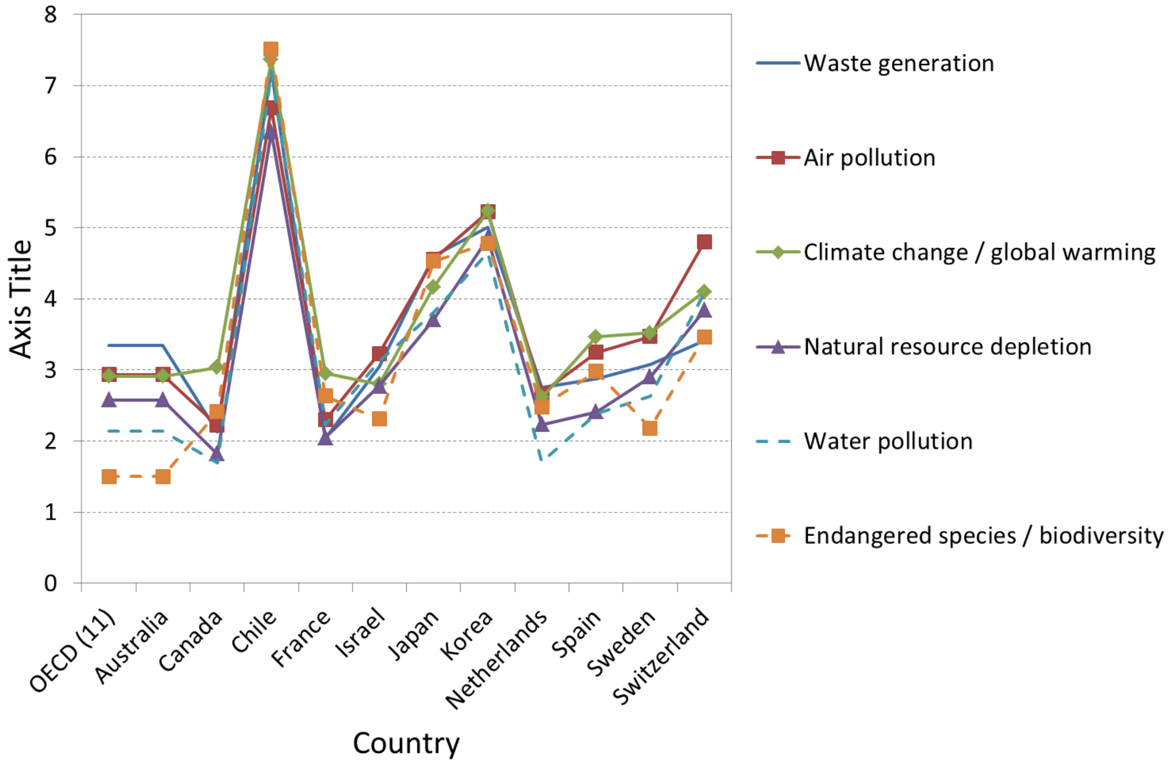
Figure 13 Share of households owning hybrid or electric cars, by country and environmental concern cluster



To get a more thorough assessment of what aspects of the environment drive persons to buy alternatively fuelled vehicles (that is, hybrid and pure electric cars), an analysis by the concern with the individual categories from the survey was conducted.

As can be seen in Figure 14, concern waste generation is surprisingly the issue that appears to convince respondents of alternatively fuelled cars the most. Air pollution and climate change have roughly the same impact here, while concern with biodiversity ranks last. It is important to note that the differences between the individual countries are by far more vast than those between the categories of environmental concern.

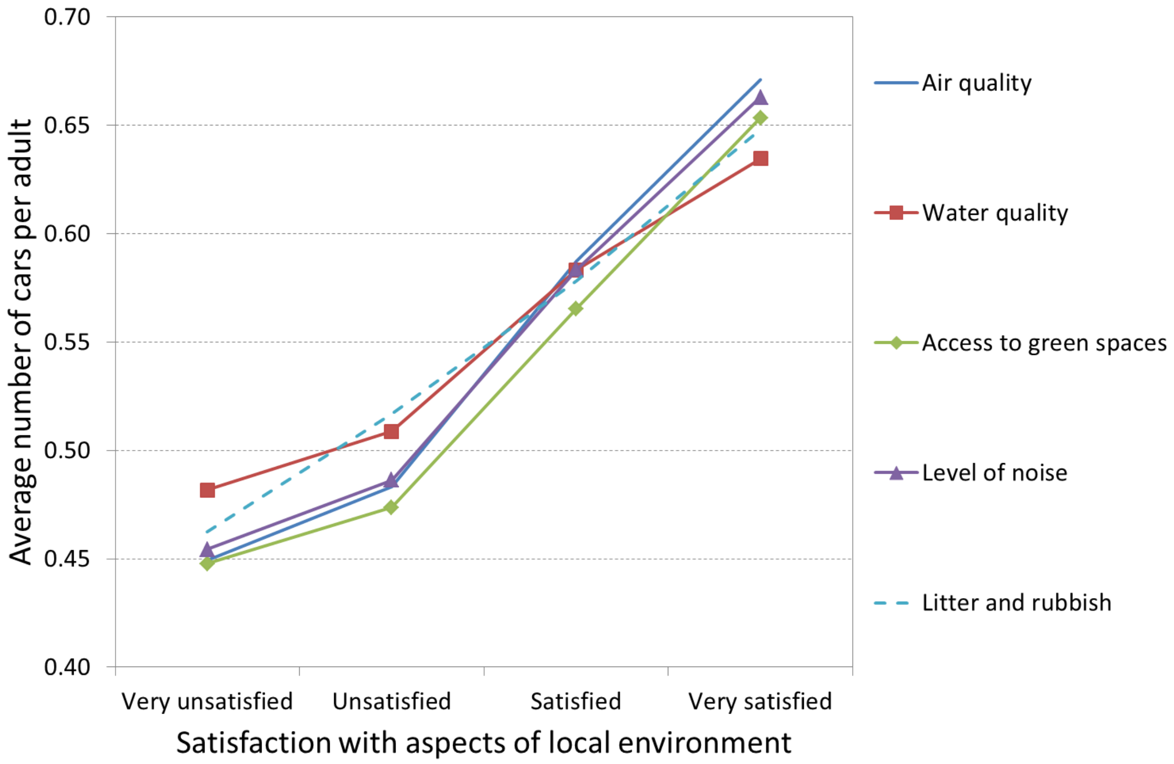
Figure 14 Share of households owning hybrid or electric cars, by country and most important environmental issue



5.6 Impact of norms and attitudes

Among the attitudinal questions that the respondents were asked to rely to, apart from those that have been covered above, indicators of satisfaction with the local environment (five different indicators, with scales from "very dissatisfied" to "very satisfied") proved to have the largest correlation with car ownership. To give proper credit to these effects, the corresponding analysis is shown in Figure 15. As can be seen, all five indicators have the same tendential influence on car ownership. Persons that are more satisfied with their local environment tend to own more cars.

Figure 15 Car ownership, by satisfaction with aspects of local environment



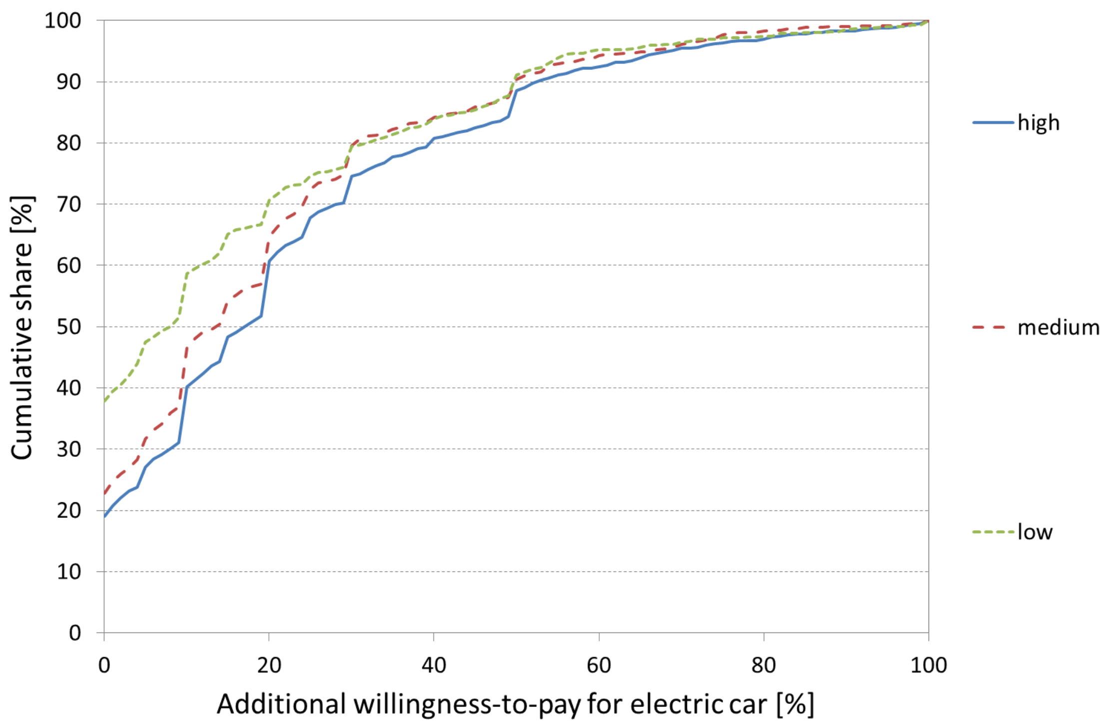
5.7 Willingness-to-pay for electric car

Figure 16 shows the distribution of the additional amount that the respondents from each environmental concern cluster would be willing to pay for an electric vehicle. This additional willingness-to-pay is given in per cent of the price of a conventional car.

In total, 24 per cent of the population would not be willing to pay more for an electric than for a conventional car. The influence of environmental attitude is clearly visible – the share of persons not wanting to pay more for an electric car is significantly higher in the "low" environmental concern cluster (38 per cent) than in the other two.

On average, the willingness-to-pay for an electric car is about 20 per cent higher than that for a conventional vehicle.

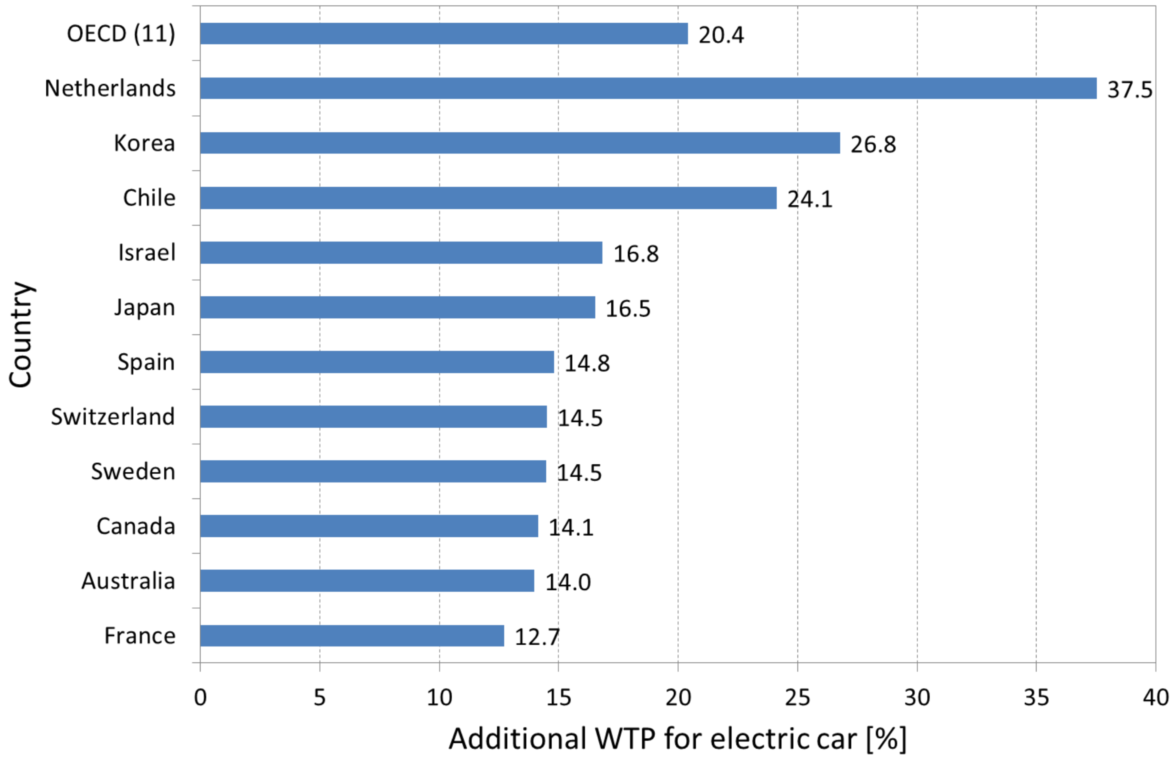
Figure 16 Distribution of additional willingness-to-pay (WTP) for an electric car



As for most of the variables of interest here, the WTP values differ among the countries involved in the study.

As Figure 17 shows, the average additional WTP over all respondents is about 20 per cent. At its peaks, it takes on values of as much as 38 per cent for the Netherlands, 27 per cent for Korea and 24 per cent for Chile. The lowest WTP values are recorded in France (13 per cent), Australia, Canada and Sweden (about 14 per cent each).

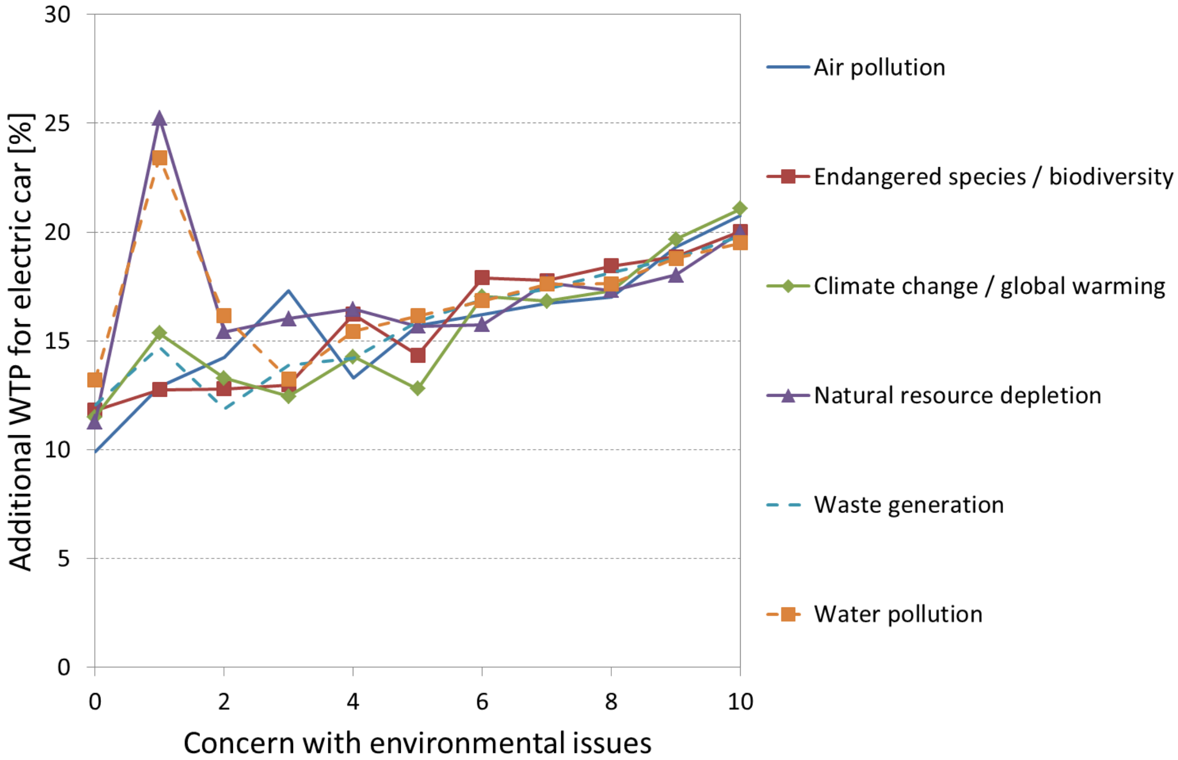
Figure 17 Additional willingness-to-pay (WTP) for an electric car, by country



To analyse in more detail what drives the respondents' WTP for electric cars, an attempt was made to more closely examine the specific impact of various attitudinal characteristics on the WTP. Figure 18 shows that, expectedly, a high concern with global warming tends to have the highest impact on the WTP for an electric car; thus, people that are highly concerned with climate change are more likely to have a higher WTP. All of the correlations are positive and the differences between the curves become smaller at high scores, confirming the above finding that overall, environmental concerns play the expected role in determining the WTP, and that this role can be expressed by one global indicator as the separate effects of the individual issues do not differ much.

The curves are flattest (and have the most fluctuations) for concerns with natural resource depletion and water pollution, at least the latter being an issue that is only remotely related to emissions from cars. Overall, the curves are quite flat from a medium concern of 6 points upwards, indicating that this is the range in which respondents are really aware of environmental issues and are ready to adapt their behaviour to accommodate better environmental conditions.

Figure 18 Willingness to pay more for an electric car, by country and most important environmental issue

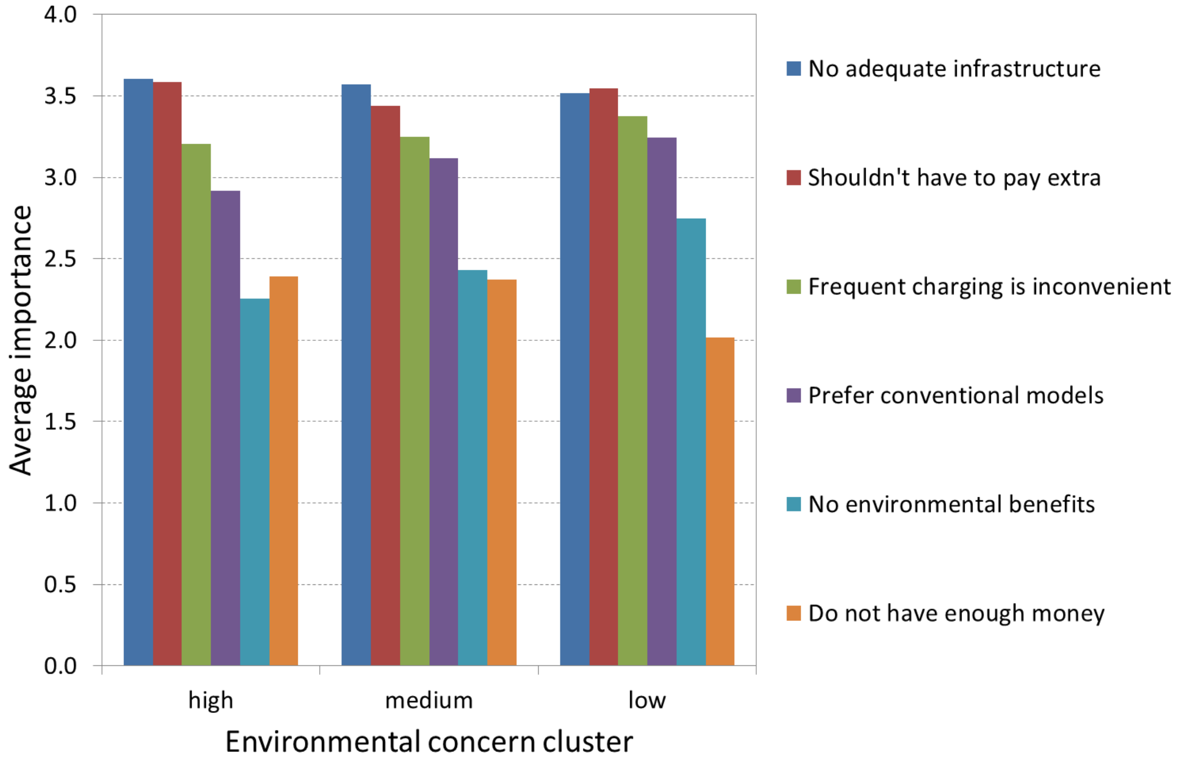


The respondents that stated a zero additional willingness-to-pay for an electric car were asked why they maintained that position. Several options were given, and were to be rated on a 1 to 4 scale. The results from the analysis of these answers by environmental concern cluster are shown in Figure 19.

The three most prominent reasons do not differ much between the three clusters – respondents do not think they should have to pay more for an electric vehicle, that adequate infrastructure is not yet available (e.g., limited number of charging stations) and, as a close corollary, that the frequent charging of electric cars is too inconvenient.

The largest difference between the three groups is the assessment of environmental benefits of electric cars. While those in the “low” environmental concern cluster often state that electric cars do not have any environmental benefits, this is less often the case in the other two clusters.

Figure 19 Reasons for not willing to pay more for an electric car, by environmental concern cluster



As can be seen in Figure 20, the overall trends regarding the reasons for not being willing to pay more for an electric car do not differ much between the 11 participating countries. While the lack of adequate infrastructure and, as a close corollary, the inconvenience of frequent charging, is an important obstacle in acquiring electric cars, affordability is the least often stated as a reason (except in Chile, Israel and Japan, where it is more important than the notion of there being no environmental benefits to electric cars). However, there also appears to be a dominant opinion that electric cars should in principle not be more expensive than regular vehicles.

As an additional indication of how attitudes are reflected in the realised behaviour of the respondents, the specific attitude of whether a person thinks that policies aimed towards environmental issues should not cost them extra money was contrasted with their willingness-to-pay for an electric car. The expectation that people who strongly agree with the abovementioned statement would have a lower WTP is confirmed by the trend in Figure 21. The WTP for an electric car of persons who strongly disagree with the statement is about 25 per cent above the cost for a regular vehicle. People who strongly agree on the other hand, state an average additional WTP of only 14 per cent.

Figure 20 Reasons for not willing to pay more for an electric car, by country

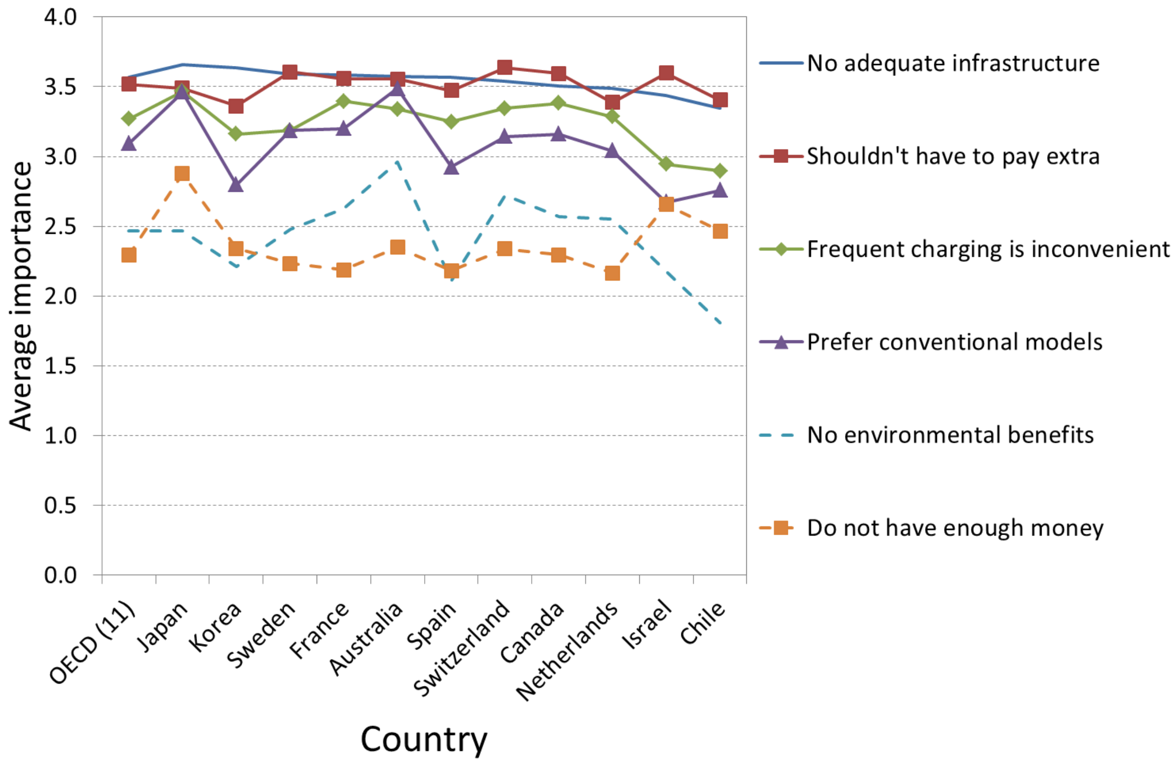
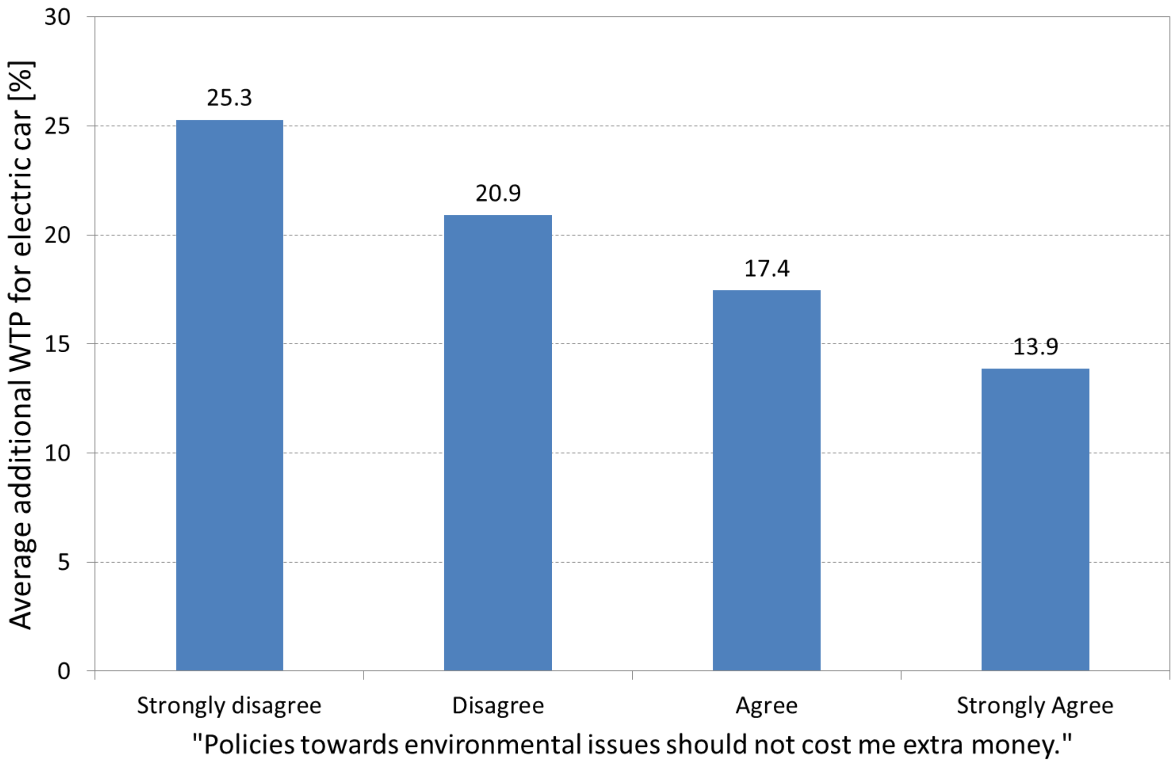


Figure 21 WTP for electric car, by attitude towards costs of environmental policies

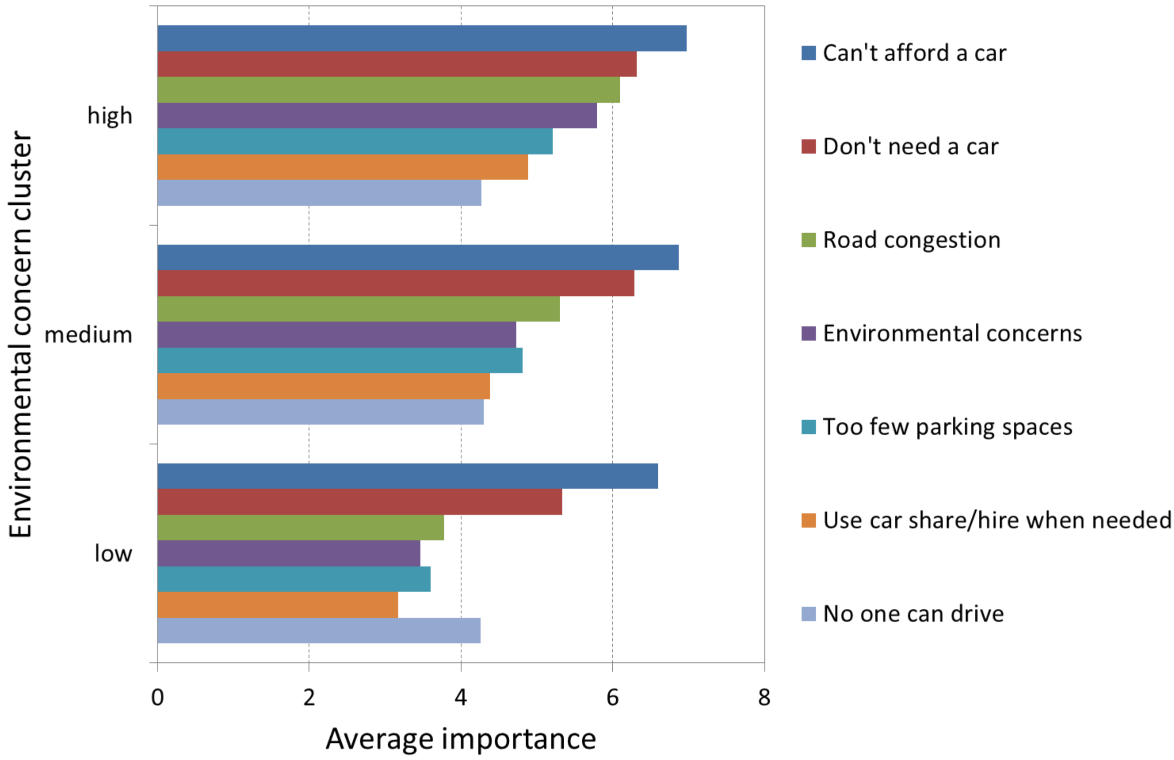


5.8 Reasons for not owning a car

For those individuals whose households do not own any cars, an analysis of the stated reasons was conducted as a function of the abovementioned environmental concern clusters. The respondents were asked to indicate the importance of various reasons on a scale of 1 to 10. As can be seen in Figure 22, the most important reasons for not owning a car are respondents not being able to afford a vehicle or not needing one. For respondents that are highly concerned with environmental issues, environmental concerns are the third most important reason for not owning a car, while they rank second-to-last for those in the low environmental concern cluster.

Interestingly, the impact of no one being able to drive, respectively owning a driving licence stays roughly the same over the environmental concern clusters. Thus, no self-selection effect seems to be present on the level of driving licence ownership (that is, persons that are environmentally aware are not less likely to possess a driving licence).

Figure 22 Reasons for not owning a car, by environmental concern cluster

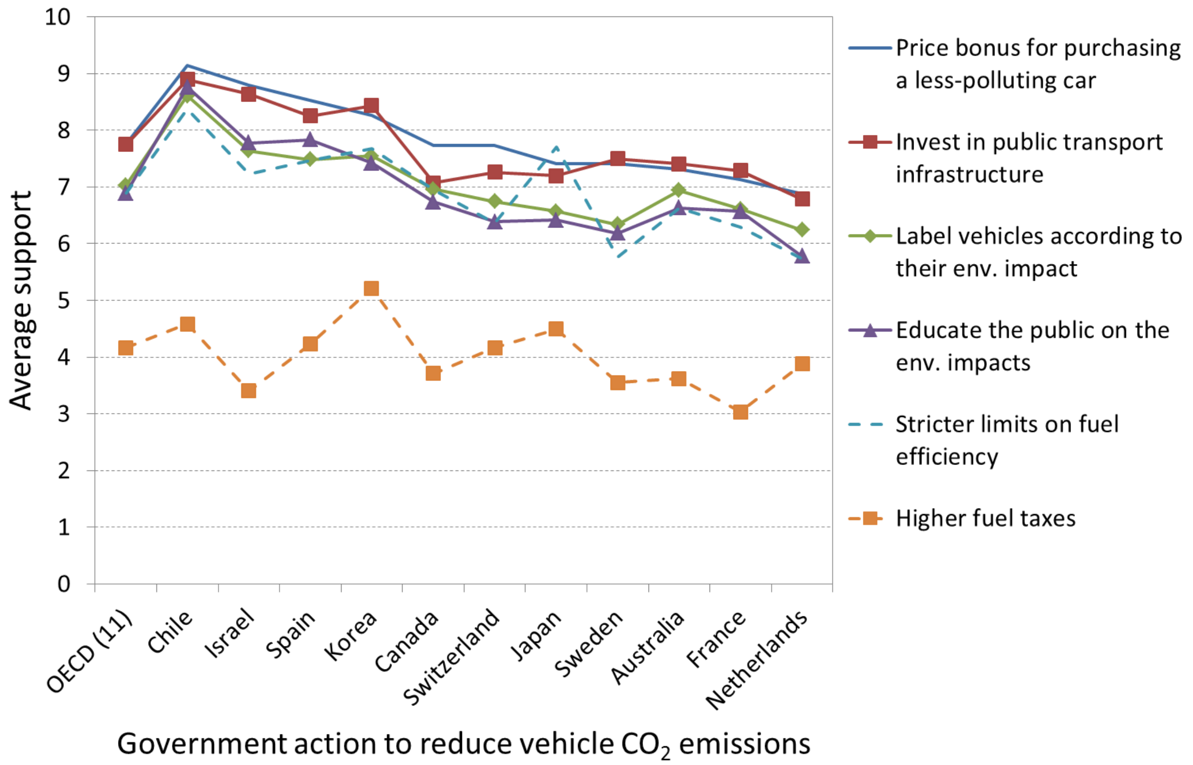


5.9 Support of government actions to reduce vehicle CO_2 emissions

When thinking of what measures to implement to reduce CO_2 emissions, authorities will be interested in how well different measures are accepted by the population. To that end, respondents were asked how strongly they would support a list of actions, on a 1 to 10 scale. The corresponding analysis is shown in Figure 23, separately for each of the 11 participating countries.

Overall, the best-accepted measures are the attribution of price bonuses for purchasing less polluting cars and investments in the public transport infrastructure, while increased fuel taxes are by far the least popular course of action in all countries. There seem to be no large differences between the countries in terms of relative popularity of the measures. The notable exception is Japan, where imposing strict limits on vehicle fuel efficiency is the best-rated measure (while it is the second least popular one in most other countries).

Figure 23 Support of government actions to reduce CO_2 emissions, by country



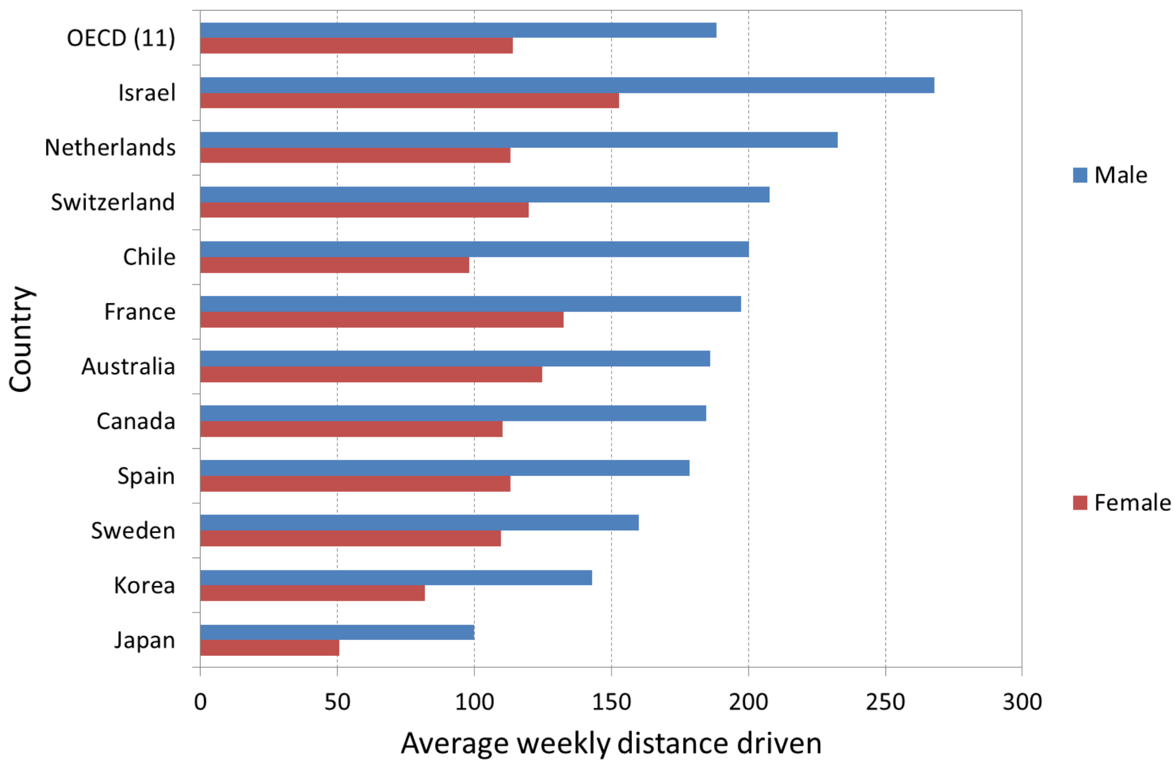
6 Car use

Car use, here expressed in weekly distances driven by the respondents, determines how heavily the environment is affected by individuals' transport choices, much more so than the car ownership rates discussed above.

6.1 Impact of socio-economic characteristics

Figure 24 shows the distribution of the average weekly distance driven by the respondents (for respondents from car owning households only) for all 11 participating countries, separately for male and female respondents. Quite surprisingly, car owners from Japan drive the least (79 kilometres per week on average). The averages are highest in Israel (211 kilometres) and the Netherlands (177 kilometres).

Figure 24 Car use, by country and gender (persons in car-owning households)

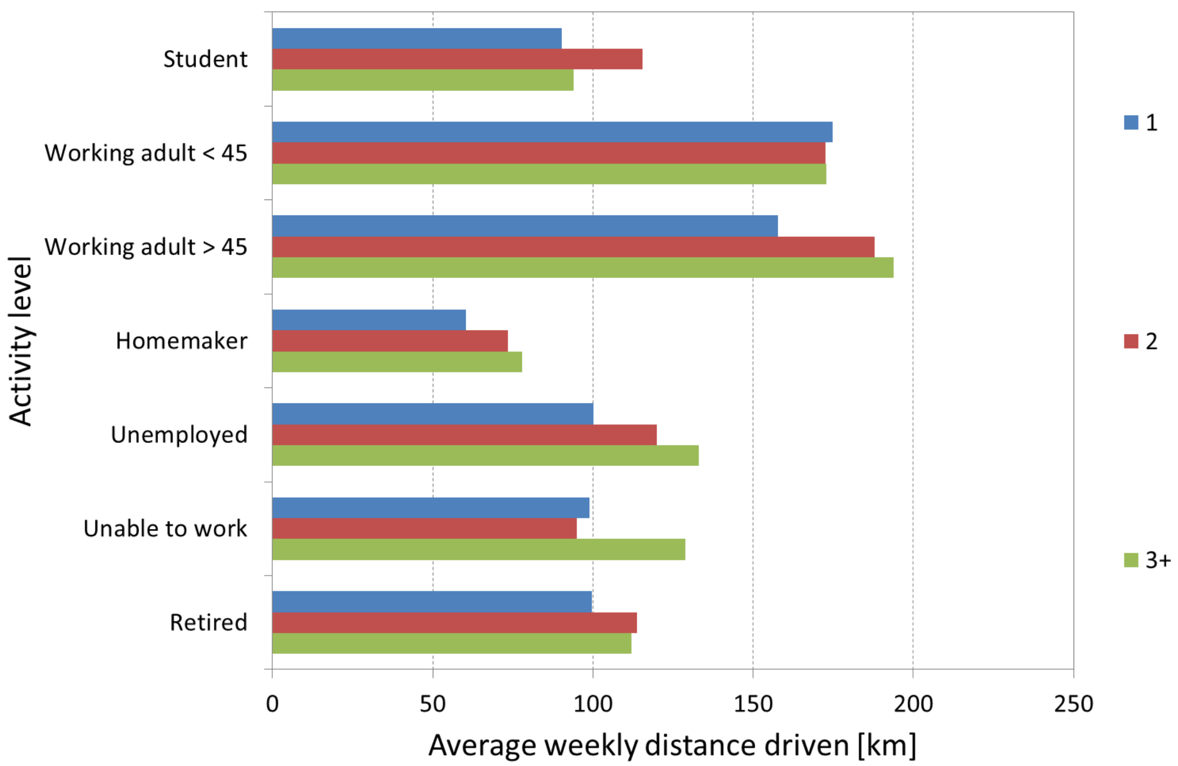


Another striking aspect of Figure 24 is the difference between men and women – males throughout the 11 participating countries drive significantly more than females. The discrepancy is the largest in the Netherlands, where men drive on average 119 kilometres (232 vs. 113) more than females, resulting in a relative difference of 105 per cent.

Another influence that was deemed important and has been pointed out in several studies (see OECD, 2011) is that of income on car use. The relationship was examined, however there seemed to be no clear trend when considering income separately from other variables (which again can only be done with an appropriate regression model) – the correlation between household income and weekly distance driven was merely 0.07 (it was however determined to be statistically significant, thus there is a slight positive influence of income on car use).

Figure 25 shows the distribution of weekly distances driven by respondents from car-owning households as a function of the respondents' activity level and household structure (size).

Figure 25 Car use, by activity level and household size



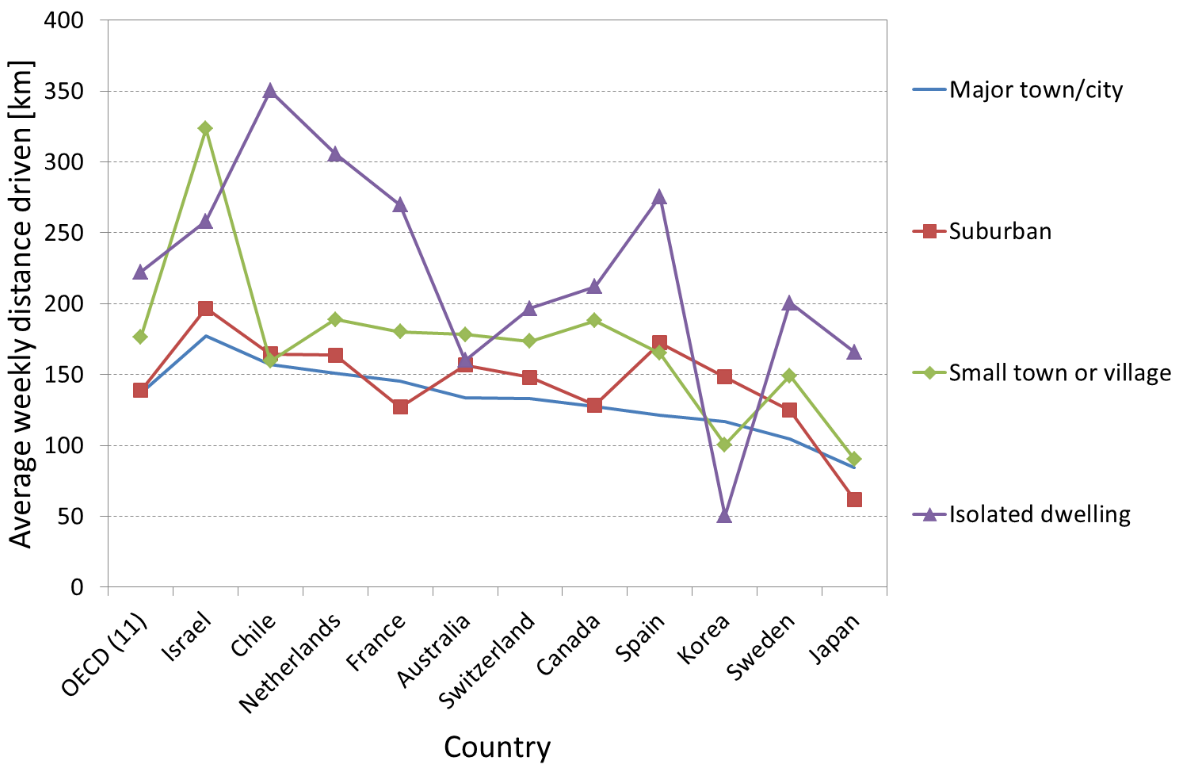
As can been seen, car use is highest among working adults of both age classes, and persons from large households tend to drive more. Unsurprisingly, the average distances are lowest for homemakers and students.

6.2 Impact of spatial characteristics

Car use, like car ownership, is affected by the area type of a person's residential location and the corresponding availability of alternative modes and destinations that are accessible by those modes. As Figure 26 shows, residents of major cities and suburbs that possess good access to public transport are likely to drive less than people from rural areas –car owners from urban areas drive less than 140 kilometres on average during a typical week (that is, less than 20 kilometres a day). The discrepancy between the urban and rural population is the largest in Israel and Chile, where villages tend to be isolated and access to infrastructure such as jobs and shopping only possible by driving long distances.

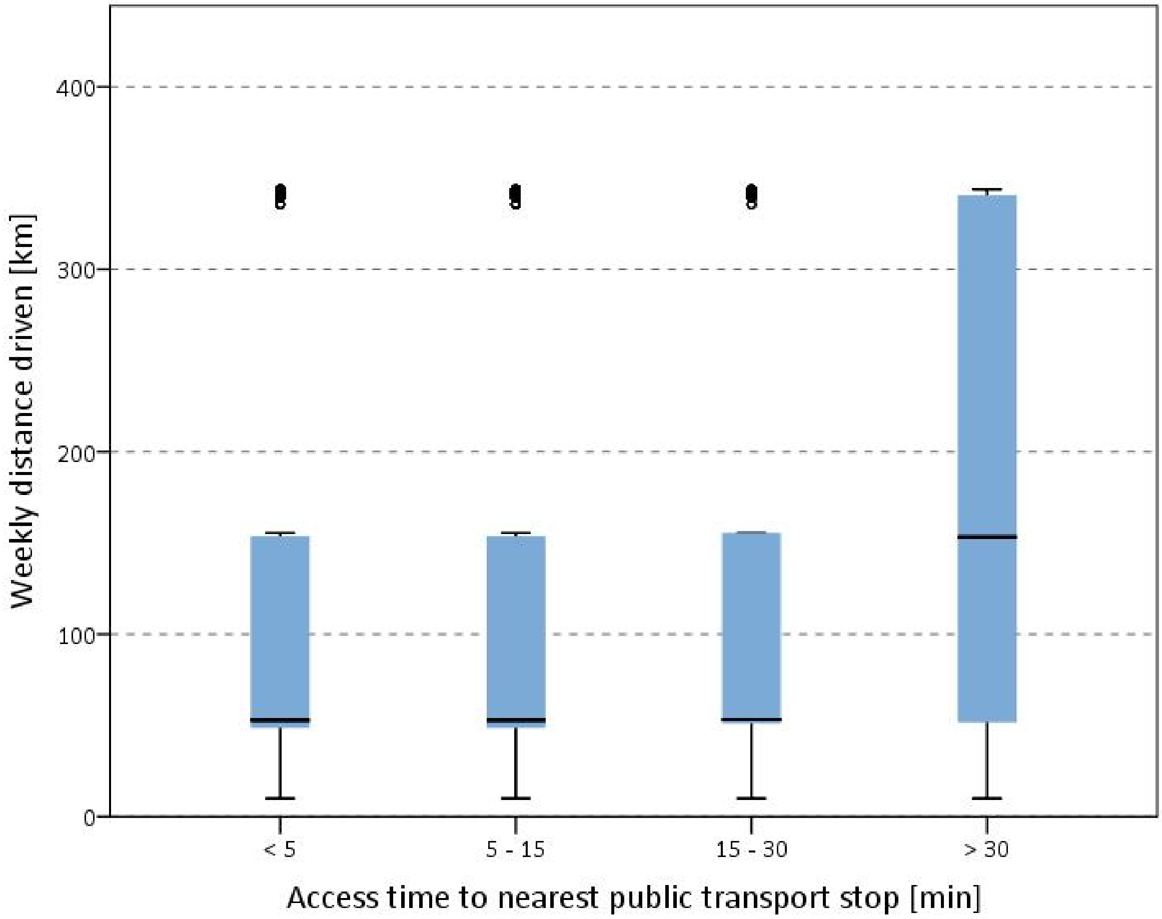
It should be emphasised again that only respondents from households that possess at least one car are considered in this analysis, thus the interaction with car ownership (and persons not owning a car naturally not driving at all) discussed in the previous section would amplify the effects presented here. Furthermore, a potential residential self-selection effect would have to be investigated in more detail on this level.

Figure 26 Car use, by country and residential area type



Another characteristic that influences car use is the access time to the nearest public transport stop from a person's home location, as Figure 27 shows. Here, the threshold beyond which car use becomes more predominant appears to lie around an access time of about 30 minutes. This influence will be further emphasised in the analysis of mode choices in chapter 7.

Figure 27 Car use, by access time to nearest public transport stop



6.3 Impact of environmental concern

It was shown above that environmentally aware respondents are less likely to own a car, although car ownership is quite high throughout the clusters. However, those respondents, that stated to be highly concerned with environmental issues and nevertheless own cars, may accommodate their environmental attitudes by using their cars less, or only for trips where no alternative is available. Again taking the average weekly distance driven by car owners as an indicator, this assumption holds overall, as Figure 28 shows.

The overall trend is quite weak, though – the difference in weekly distance driven between respondents from the “low” and “high” environmental concern clusters is merely 10 per cent. In individual countries, the differences can become larger, reaching more than 100 per cent in

Sweden. In some countries, such as, Chile, Korea and Japan, the trend is even inverse. The interpretation is that environmental issues only have a marginal impact on respondents' driving behaviour in those countries and that again, it would have to be measured in a modelling framework incorporating all possible effects and interactions.

The influence of concerns with individual issues is shown in Figure 29.

Figure 28 Car use, by country and environmental concern cluster

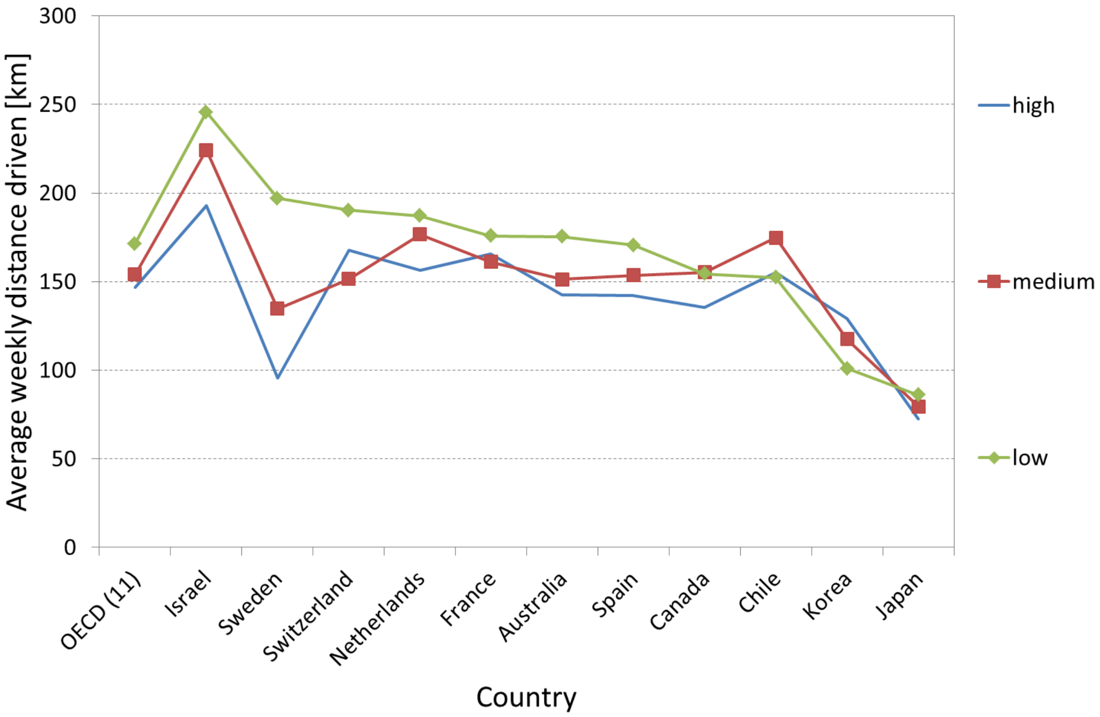
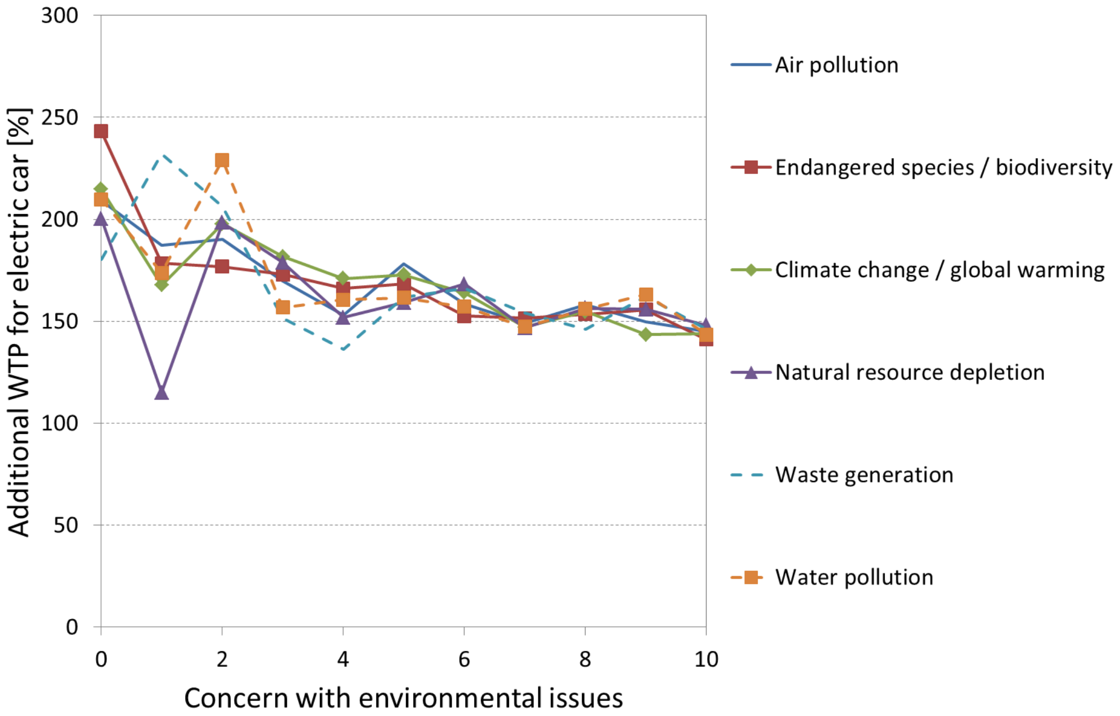


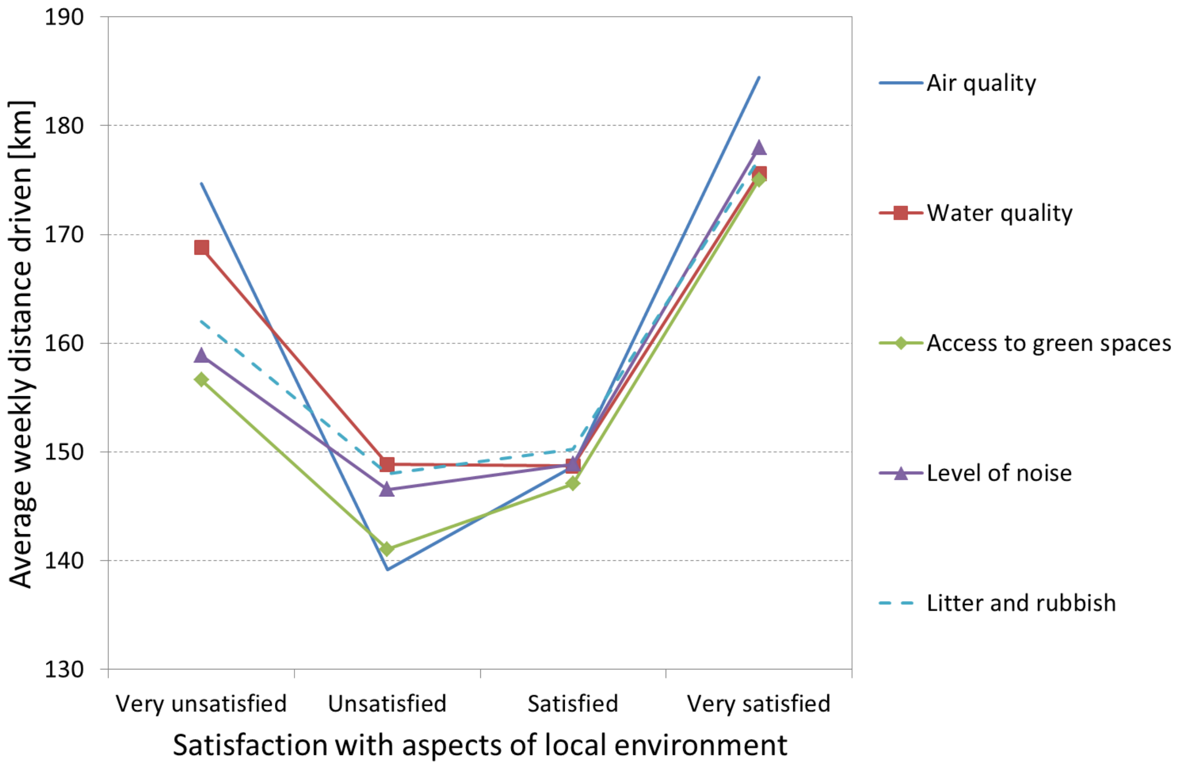
Figure 29 Influence of environmental concerns on car use



6.4 Impact of norms and attitudes

When assessing what attitudinal characteristics might influence the respondents' decisions on how much to drive their cars, satisfaction with the local environment was again expected to have an effect. In Figure 30, two effects can be observed. First, the impact of all five indicators is again roughly the same. Satisfaction with air quality seems to have the largest impact, but only marginally so. Second, and more surprisingly, respondents stating the two extreme satisfaction values exhibit higher car use rates than those in-between. It is possible that those who are very satisfied with their local environment deem it unnecessary to do anything to preserve it, and thus drive the most; the other end of the scale might be due to a certain sense of fatalism – if respondents are very unsatisfied with their situation, they might become reluctant to do anything to change it. The in-between satisfaction categories appear to be those where a sense of willing – and being able – to change and preserve the conditions prevails.

Figure 30 Car use, by satisfaction with aspects of local environment

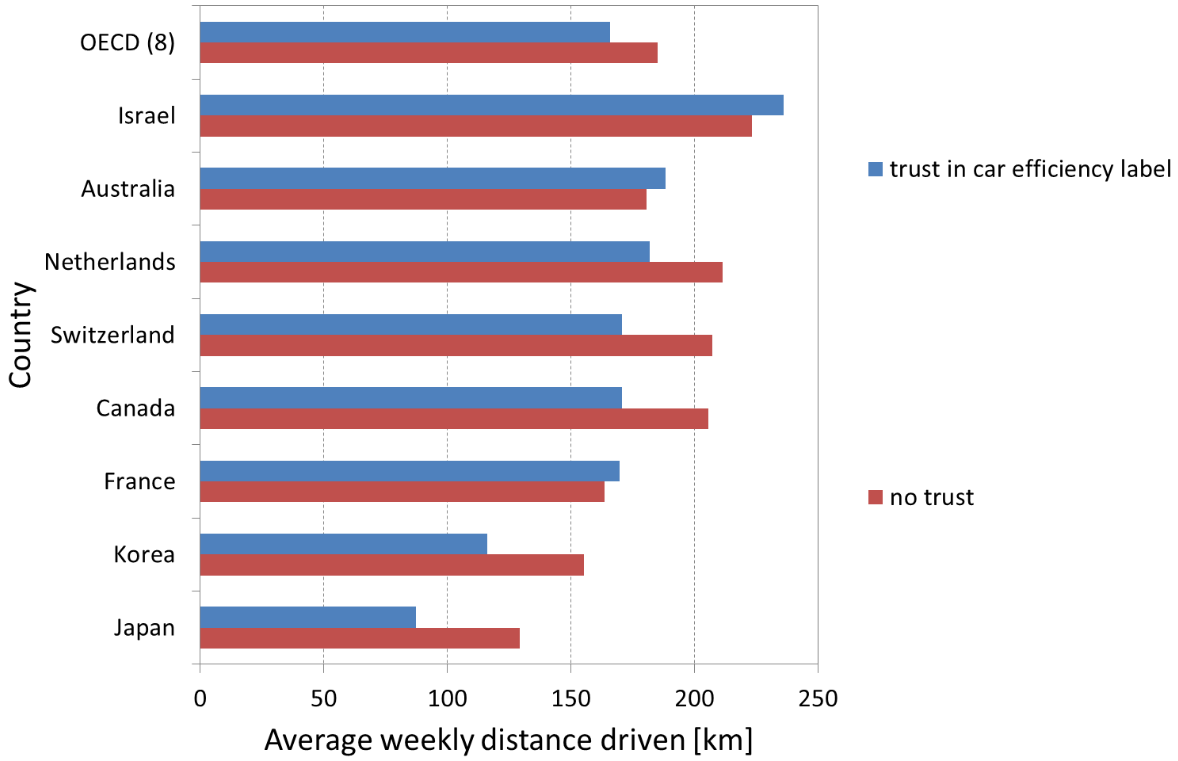


6.5 Impact trust in labels

In the survey, the respondents from a subset of the participating countries were presented with several logos and labels and asked whether they were familiar with these labels, whether they deemed them trustworthy, and whether they used them when making purchasing decisions. One of those labels was one relating to car efficiency. The effects of trust in this label on car use is shown in (similar effects for car choice, relating to fuel types, consumption, or willingness-to-pay for electric cars, could not be found).

As Figure 31 shows, trust in car efficiency labels has a weak average impact on car use; in 3 of the 8 countries where the question was asked, the trend is even the inverse of what one would expect, that is those respondents trusting the label actually drive more than those who don't. From this, and from the absence of any corresponding effects on car choice (where they would have been expected to be more visible), it can be concluded that labelling has only a marginal, if any, effect on travel behaviour in this context.

Figure 31 Impact of trust in car efficiency label on car use



6.6 Incentives for driving less

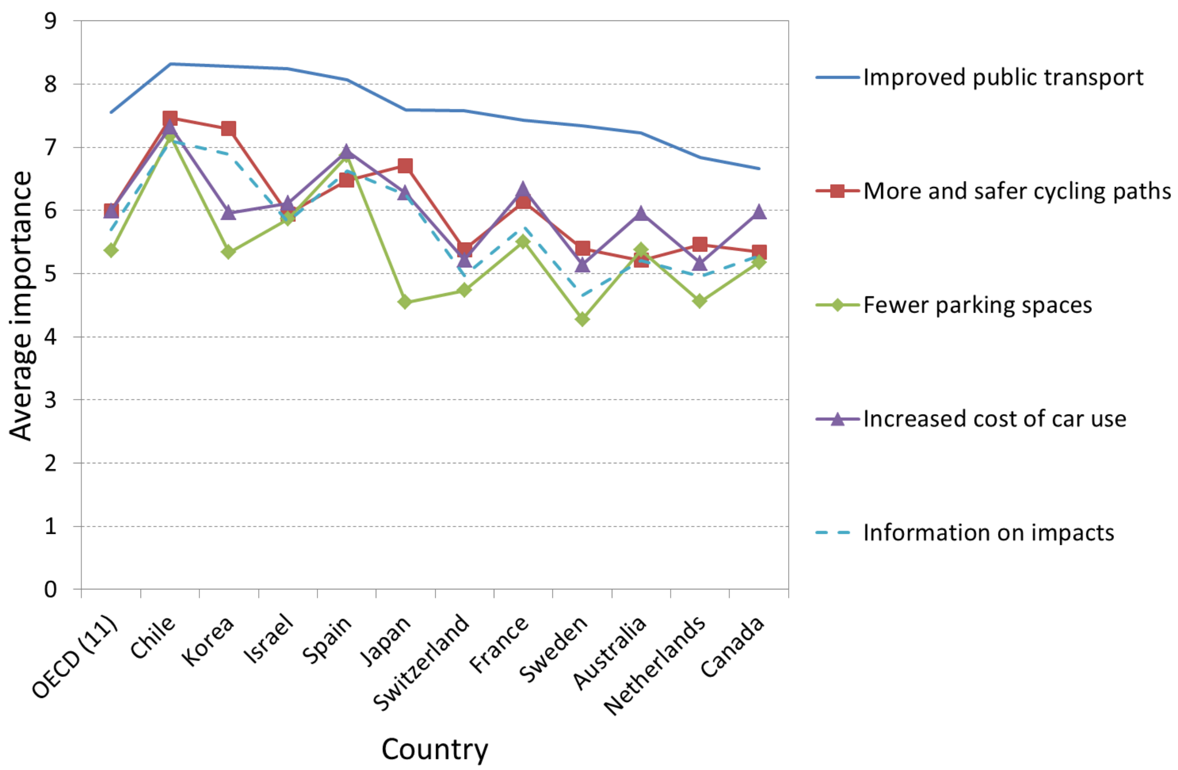
The respondents to the survey were asked what factors would encourage them to drive less, and to rate those factors on a 1 to 10 scale.

As Figure 32 shows, improved public transport options would be by far the most effective measure to encourage less car use. In the same vein, the addition of more and safer cycling paths would also encourage the use of alternative modes, particularly in Chile, Korea and Japan.

Surprisingly, the expected effects of increased costs for car use would be quite moderate (which is however consistent with the reduced support for higher fuel taxes shown in Figure 23), as would be those of more information on the environmental impacts of driving relative to other means of transport.

Parking availability appears to be the least suited policy tool to reduce car use, which, at least for Switzerland, is surprising. A recent study by conducted at IVT by Weis *et al.* (2011) emphasised parking policies, and significant effects on mode choice were established.

Figure 32 Factors encouraging less driving, by country



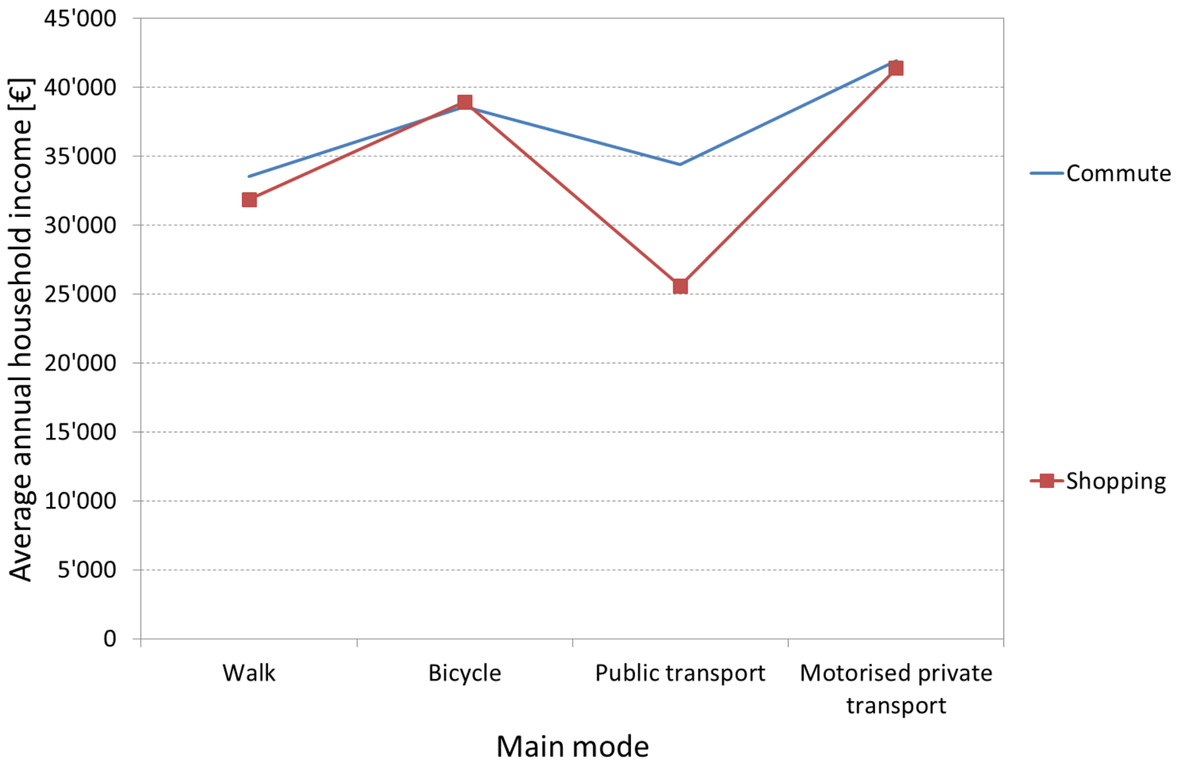
7 Determinants of mode choice for frequent trips

In the survey, various attributes of the respondents' everyday travel were recorded, more specifically of their trips to work and the most common shopping location. Respondents were asked to specify their most common mode for reaching those destinations, the duration of those trips, and the attributes of the available alternatives.

7.1 General trends

As a general trend, Figure 33 shows the influence that household income has on mode choices. It can be seen that for both commute and shopping trips, respondents travelling by car tend to be wealthier that those using public transport.

Figure 33 Influence of income on commute and shopping mode shares



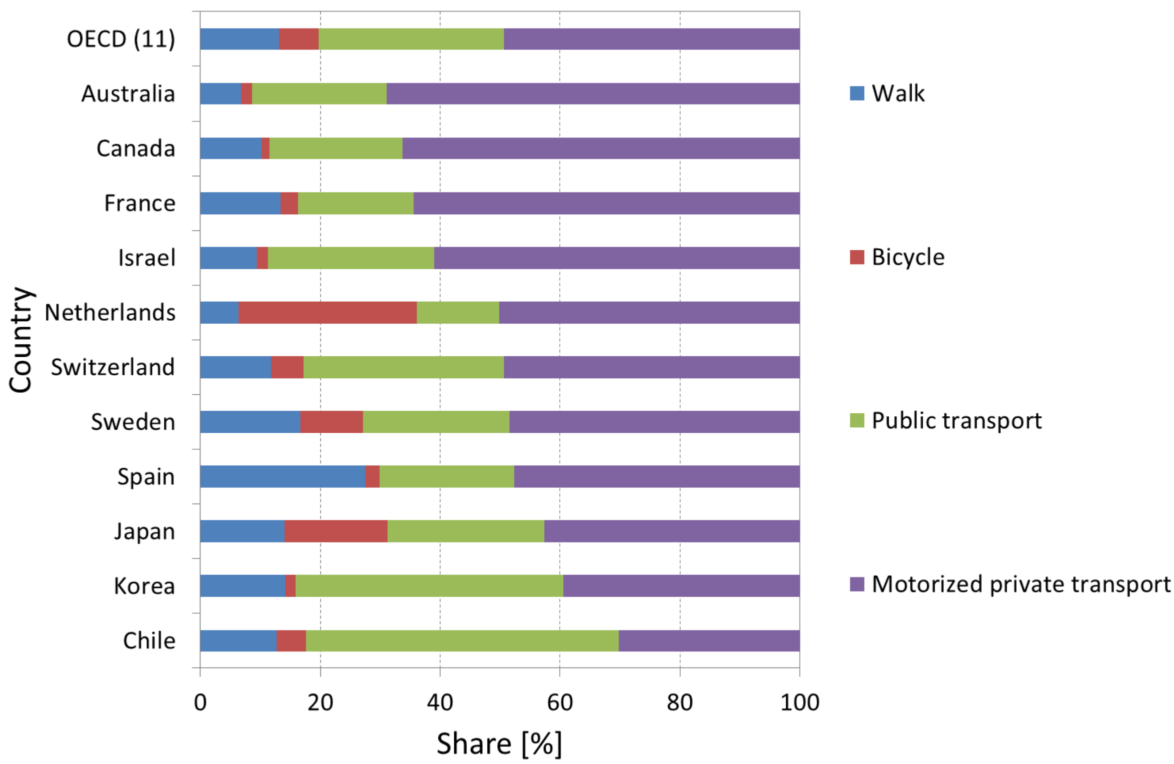
For a more detailed analysis of behaviour, the following sections provide analyses of the most interesting effects on mode choice for commute and shopping trips separately.

7.2 Commute trips

7.2.1 Mode shares by country

The distribution of the main modes used for commuting to work is shown in Figure 34, again separately for each of the 11 participating countries. Australia and Canada have the largest share of car commute trips, while public transport is predominant for work trips in Chile, Korea and Japan. The share of walking in commute trips is largest in Spain, while bicycle has the largest share in the traditionally bike affine Netherlands (Pucher and Dijkstra, 2003).

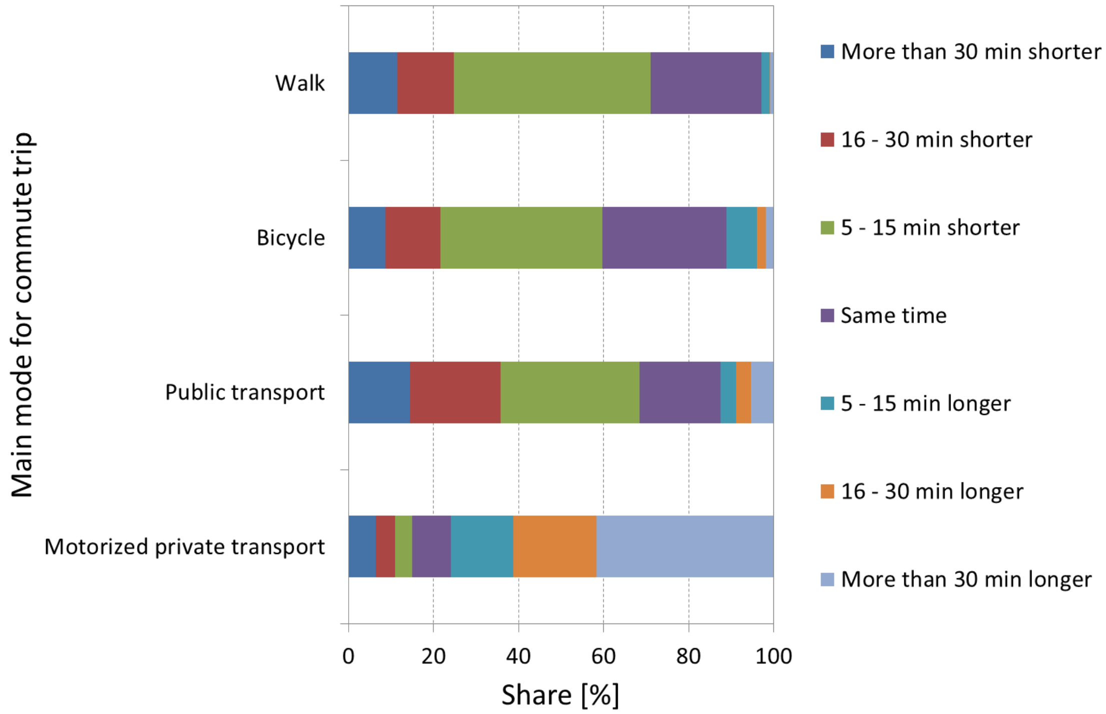
Figure 34 Mode shares for commute trips, by country



7.2.2 Influence of trip attributes

As Figure 35 shows, the choice of a travel mode for the commute trip is heavily driven by the corresponding travel time. In 76 per cent of cases where the car is the most often chosen mode for the commute trip, it is the shortest available alternative (that is, the travel time for the fastest other available mode is at least 5, and in the majority of cases even more than 30 minutes, longer). On the other hand, respondents travelling by other modes often do so despite there being faster available alternatives (mostly the car). This is a first indicator that people trade off travel time for not commuting by car, be it for environmental, financial or other reasons.

Figure 35 Main mode for commute trip, by travel time for fastest alternative



There is a clear difference of travel time distributions between the different modes, as Figure 36 shows. Walk and bicycle are considered viable options practically only for short trips (where it takes below 30 minutes to get to work by those means). On the other hand, a majority of public transport commute trips are over 45 minutes long. Here, public transport is preferred to driving, probably because the long trip can be spent at secondary activities (reading, working, etc.; see for example Ohmori and Harata, 2008, for a corresponding analysis in Japan). Most car trips fall in the range between 15 and 45 minutes.

Another variable that influences commute mode choice behaviour (and for which a similar effects has already been shown in the context of car use in Figure 27) is the access time to the nearest public transport stop. As Figure 37 shows, public transport is the most likely to be chosen when the access time to the stop is low. The threshold appears to be at 15 minutes, over which the share of public transport drops off considerably, in favour of higher shares for the car alternative.

Figure 36 Distributions of commute travel times, by mode

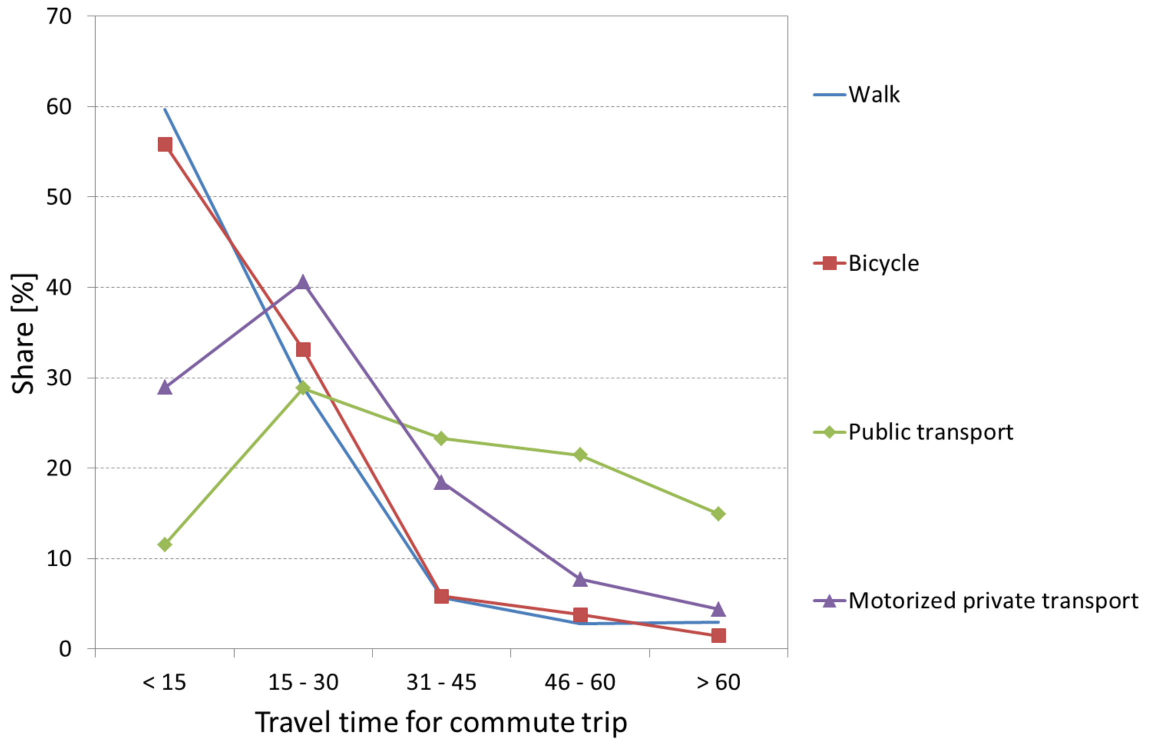
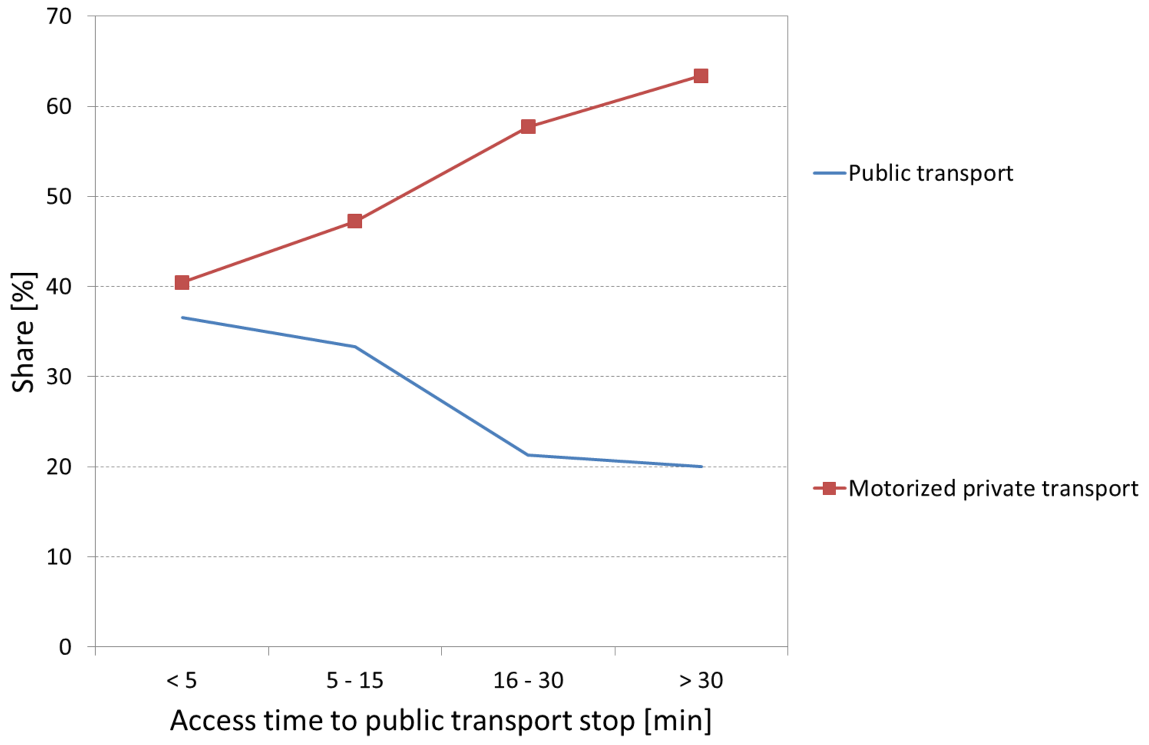


Figure 37 Main mode for commute trips, by access time to public transport stop



7.2.3 Impact of socio-economic characteristics

The socio-economic characteristics of the respondents are evidently of high importance for their commute mode choices. The influence of the respondents' activity level in interaction with their gender is shown in Figure 38 (as both have been shown to influence car use very significantly, see Figure 24). Students are more likely to commute by public transport than working adults, in large parts due to their lower car ownership.

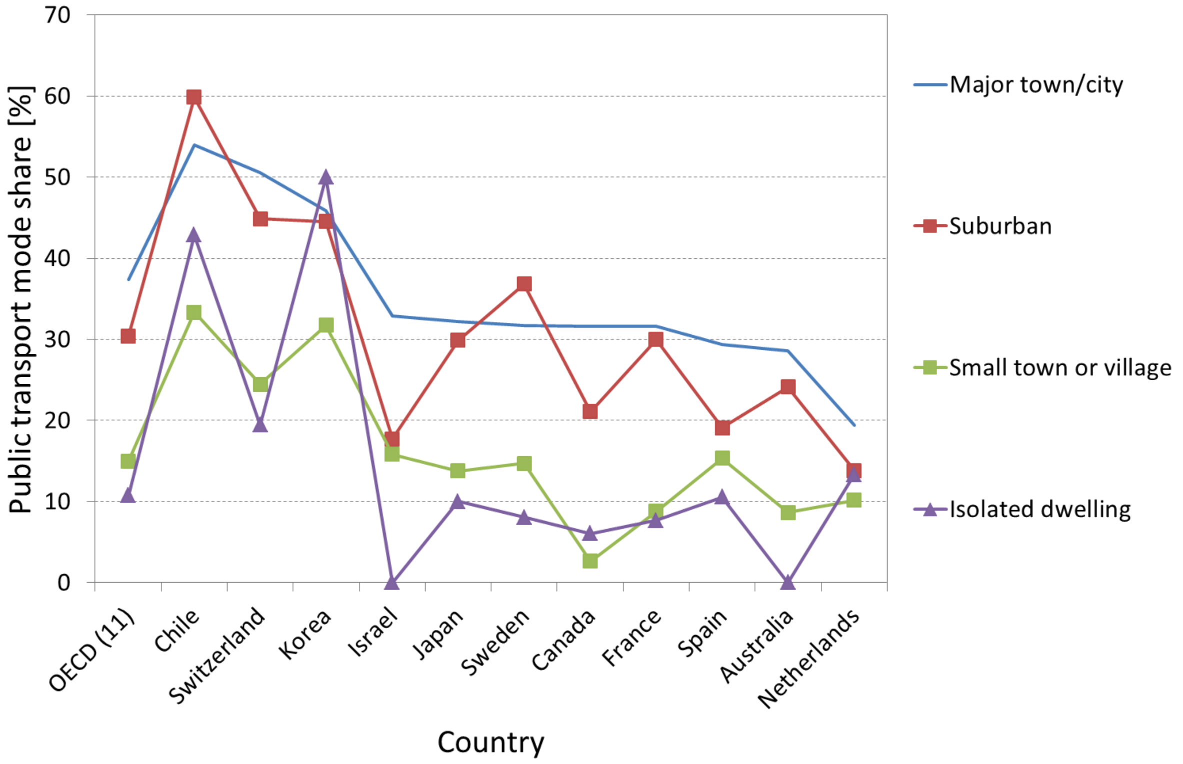
Overall, men commute significantly more by car than women (the highest difference being 9 per cent in the category of working adults above the age of 45). This is in line with recent results for Switzerland (Weis *et al.*, 2009, 2011).

Figure 38 Public transport and car mode shares for commute trips, by activity level and gender

7.2.4 Impact of spatial characteristics

As is the case for car use (Figure 26), the spatial type of the respondents' residential location has a strong influence on mode choice as well, as is evidenced by Figure 39. While public transport shares for commute trips are high for respondents living in cities or suburban areas, it is significantly lower in rural areas. There are, however, vast differences in these trends among the 11 participating countries. Especially in Chile and Korea, the share of public transport among residents of isolated dwellings is very high.

Figure 39 Public transport mode shares for commute trips, by country and residential area type



7.2.5 Impact of environmental concern

The influence of environmental attitudes on mode choice is shown in Figure 40. Here, it can be seen that the influence of environmental concern is quite large. Respondents that are highly concerned with environmental issues have a significantly different mode choice profile, and a car modal share that is 15 per cent lower than that of the lowest cluster. Interestingly, the trade-off happens only between car and public transport, the modal shares for the slow modes (walk and bicycle) staying roughly the same across clusters.

An interesting interaction to be considered here is between accepted access time to the public transport stop (which, on average, has been shown to be around 15 minutes; Figure 37) and environmental concerns as given by the clusters. An indication of this valuation is given by Figure 41. While the abovementioned influence of environmental concerns on mode choice is clearly visible here, the access time level at which the drop-off towards more car use happens appears to be roughly the same for all three clusters.

Figure 40 Main mode for commute trips, by environmental concern cluster

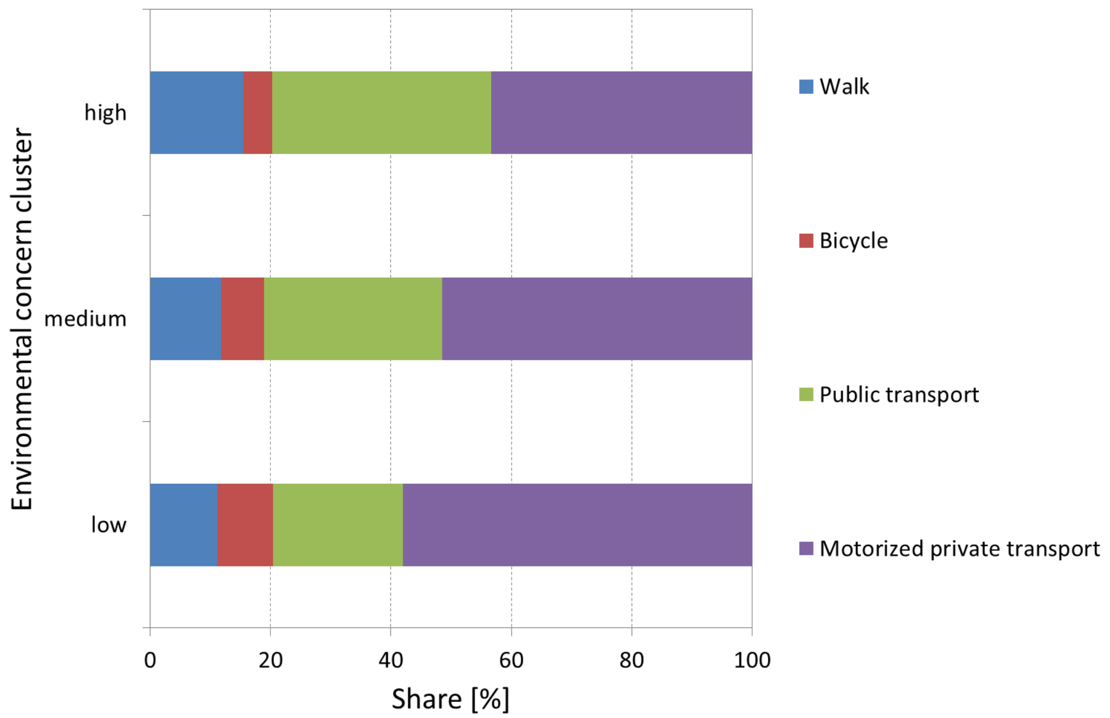
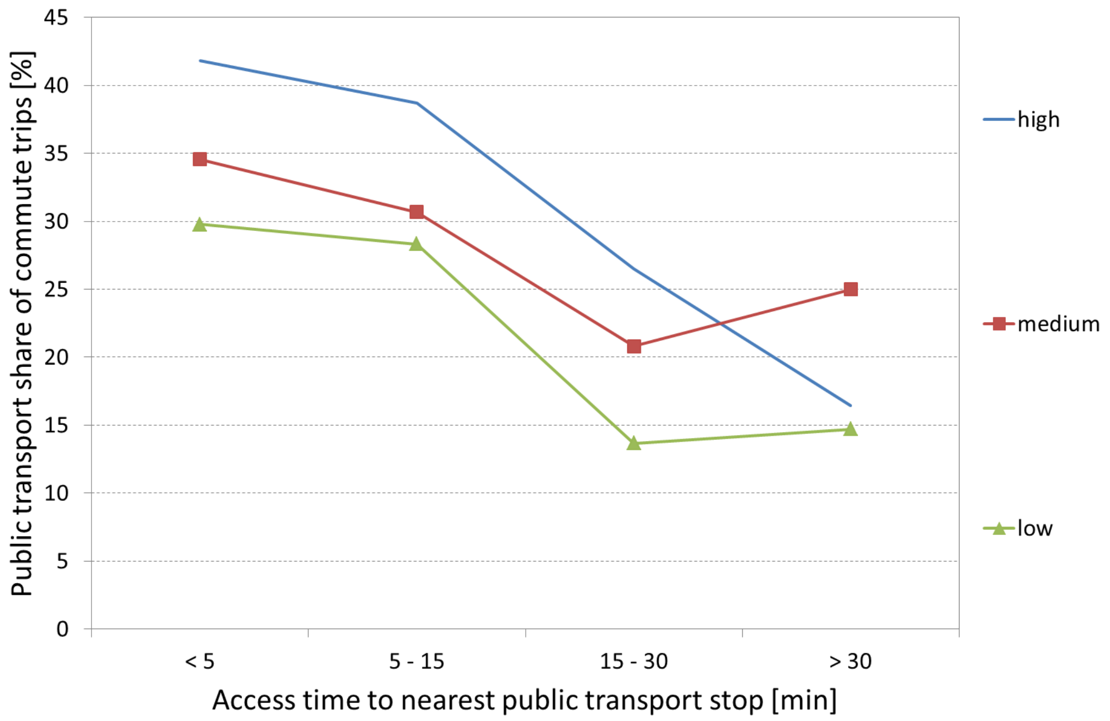


Figure 41 Public transport share in commute trips, by distance to public transport stop and environmental concern cluster



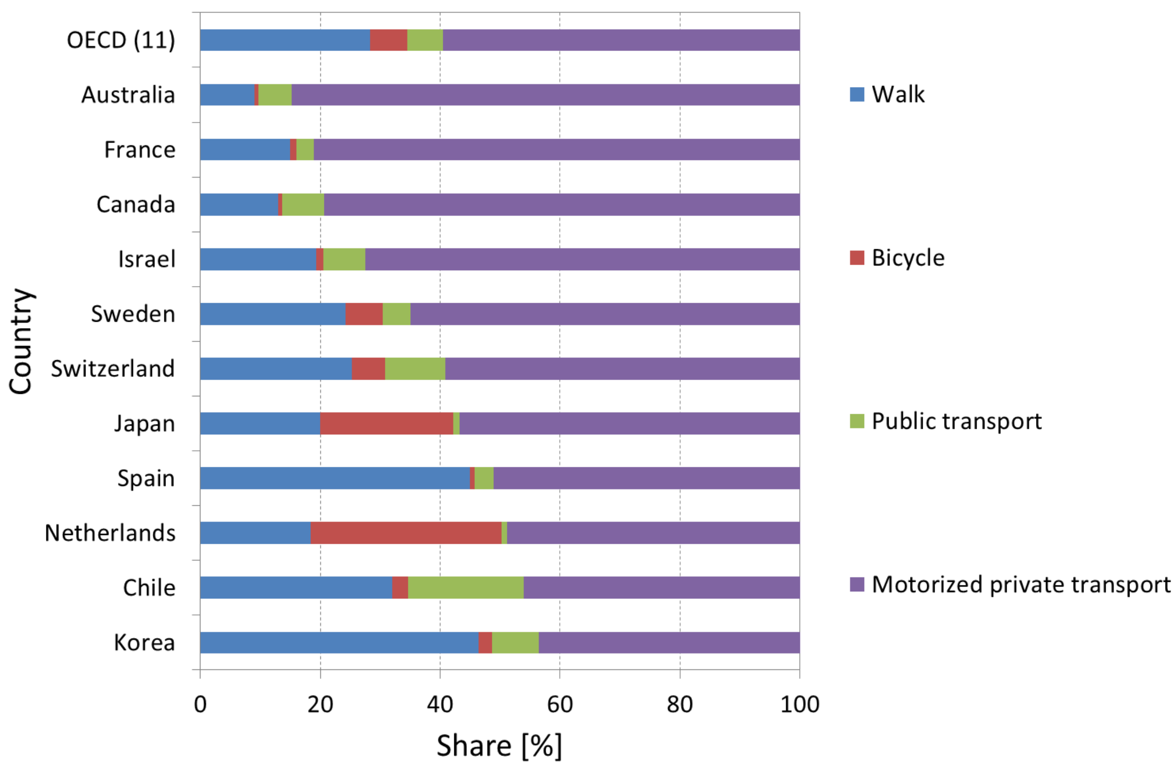
7.3 Shopping trips

7.3.1 Mode shares by country

For shopping trips, the trends regarding mode shares is completely different from commute trips, as the main mode distributions in Figure 42 show. Here, public transport plays practically no role in any of the 11 countries – a large majority of trips are carried out either by car or on foot. This is in line with recent Swiss results (Weis *et al.*, 2011), where driving was shown to be inherently preferred to other modes for shopping trips. The decision for a mode is influenced by the distance, respectively travel time, to the shop (the corresponding variable was not available in the data set, though), and probably by the quantity and nature of the purchased goods.

Australia and Canada again have the largest shares of car trips, which may be explained by shopping opportunities often being located in malls on the outskirts in those countries, as opposed to close-by, smaller and specialised shops.

Figure 42 Main mode for shopping trips, by country

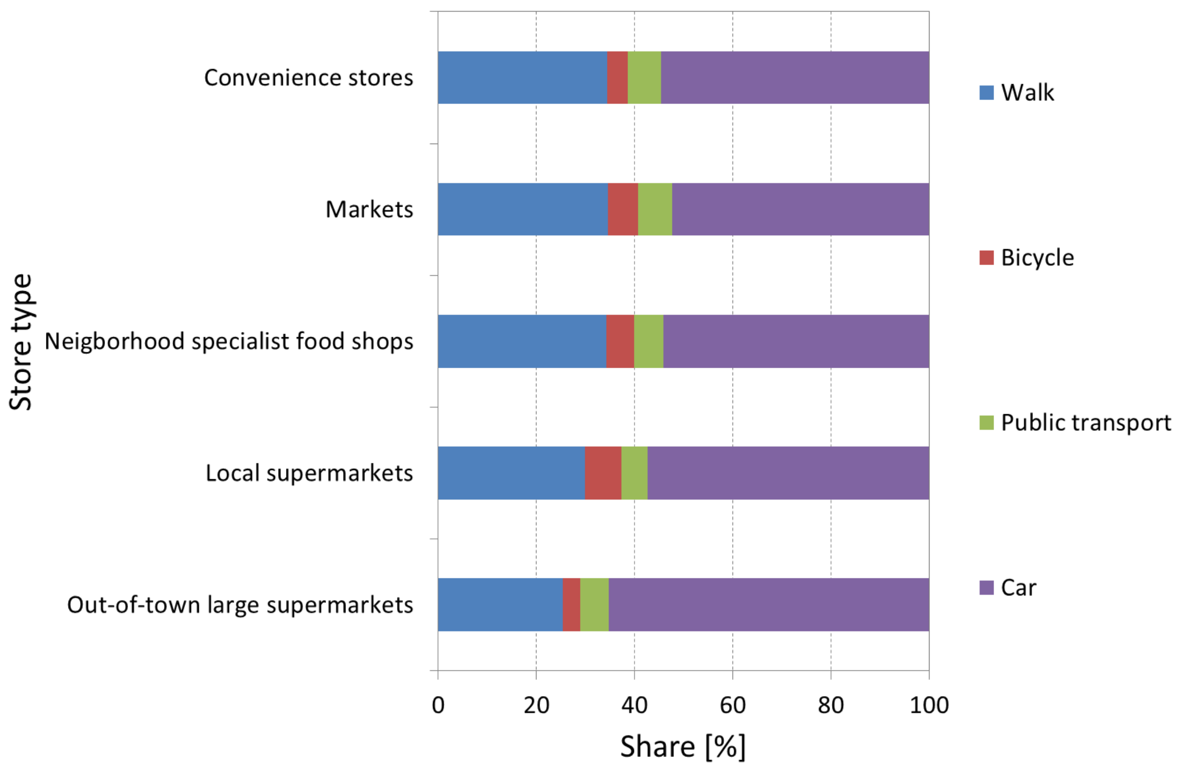


7.3.2 Influence of type of shopping location

The respondents were asked where they shop for food in a normal week, with several possible answers being offered. Figure 43 shows the shares of main shopping modes for each of the options.

Expectedly, the share of car trips is highest for respondents who frequently shop at out-of-town large supermarkets. For local supermarkets, specialist shops, markets and convenience stores, the modal split shifts towards walking, as those stores are probably in closer distance to the respondents' home locations. Overall though, the share of car trips is very high, and that of public transport and bicycle nearly negligible.

Figure 43 Main mode for shopping trips, by store type



7.3.3 Other influences

Analogous analyses to those for the commute trips shown in section 7.2 were carried out for the shopping trips, where the corresponding variables were available. As the main findings were roughly the same as for the commute trips, with the exception of car mode shared being significantly higher throughout, the corresponding figures are shown below, but left uncommented.

Figure 44 Main mode for shopping trips, by access time to public transport stop

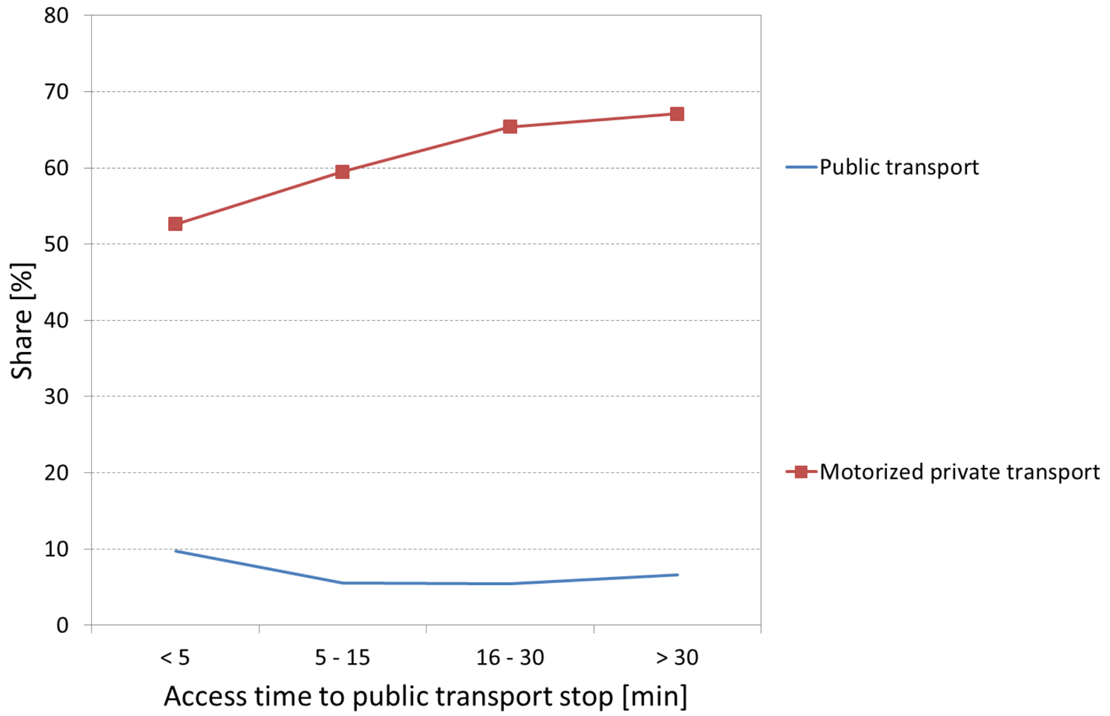


Figure 45 Public transport and car mode shares for shopping trips, by activity level and gender

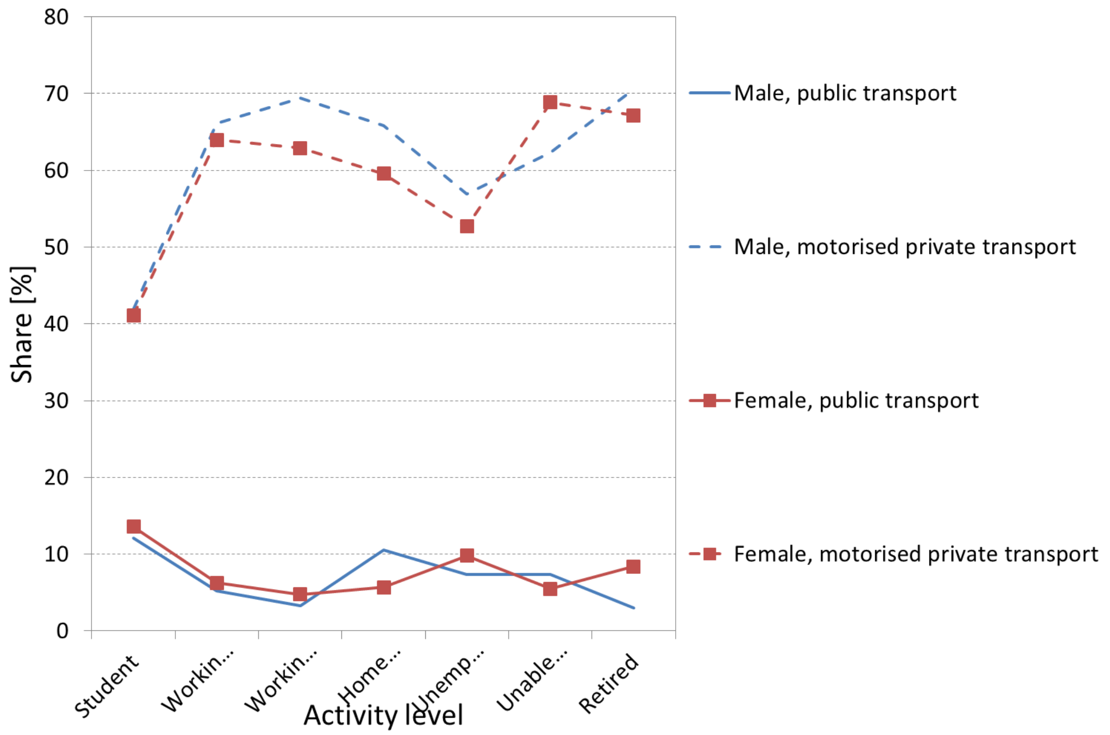


Figure 46 Public transport mode shares for shopping trips, by country and residential area type

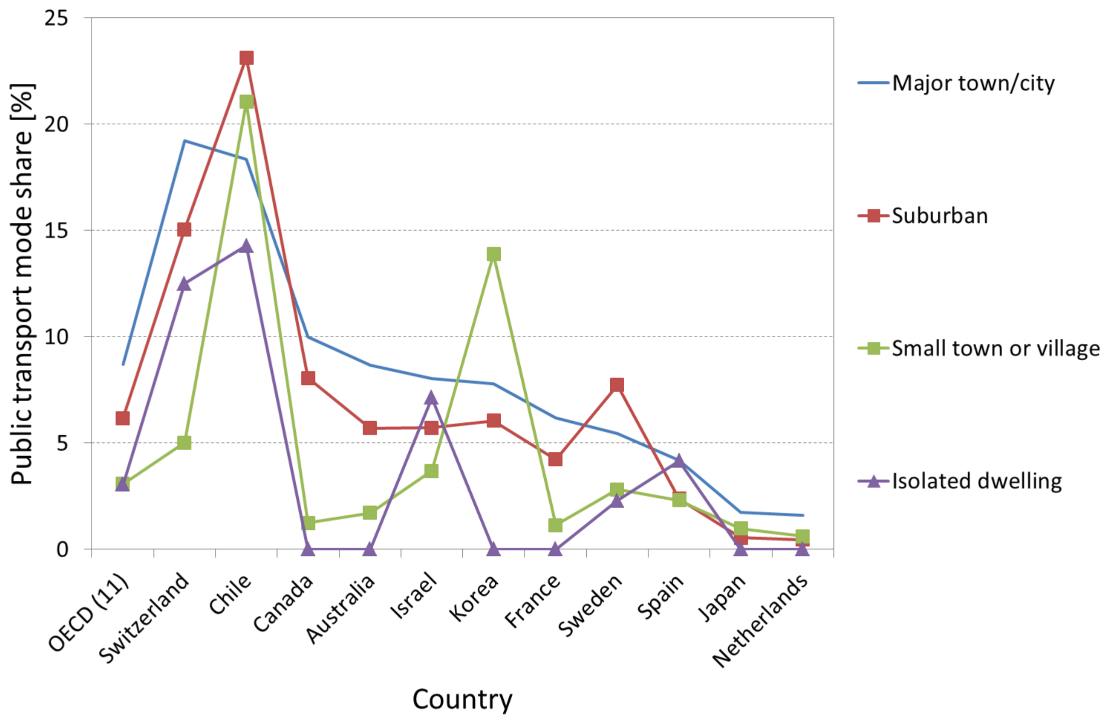


Figure 47 Main mode for shopping trips, by environmental concern cluster

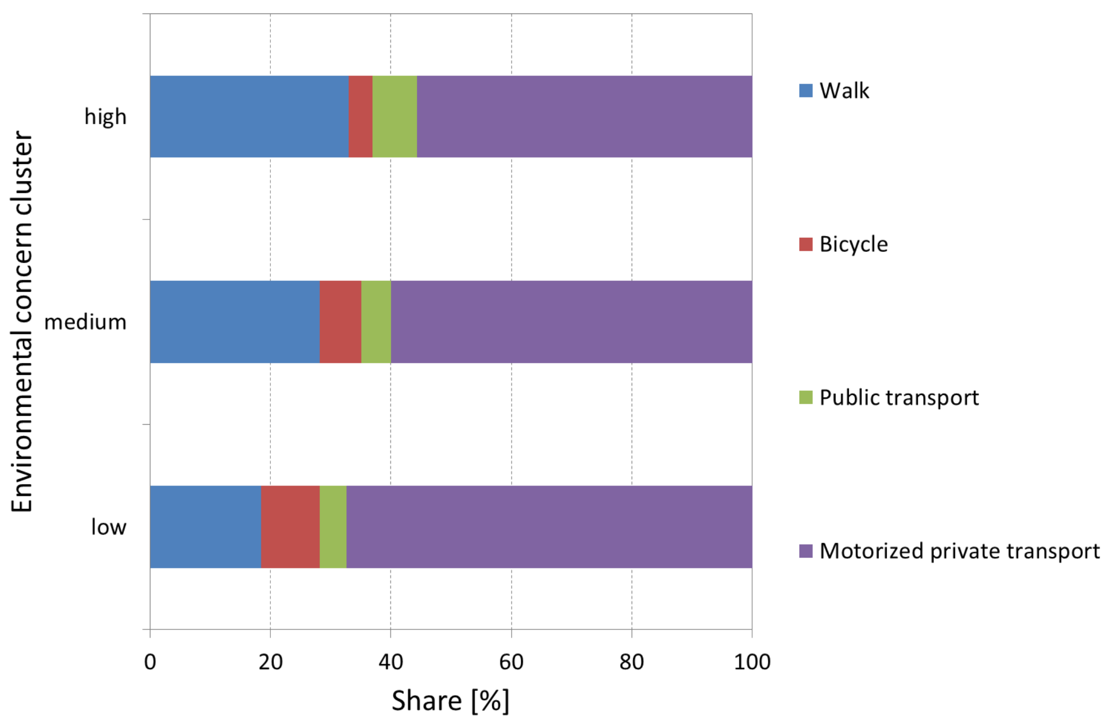
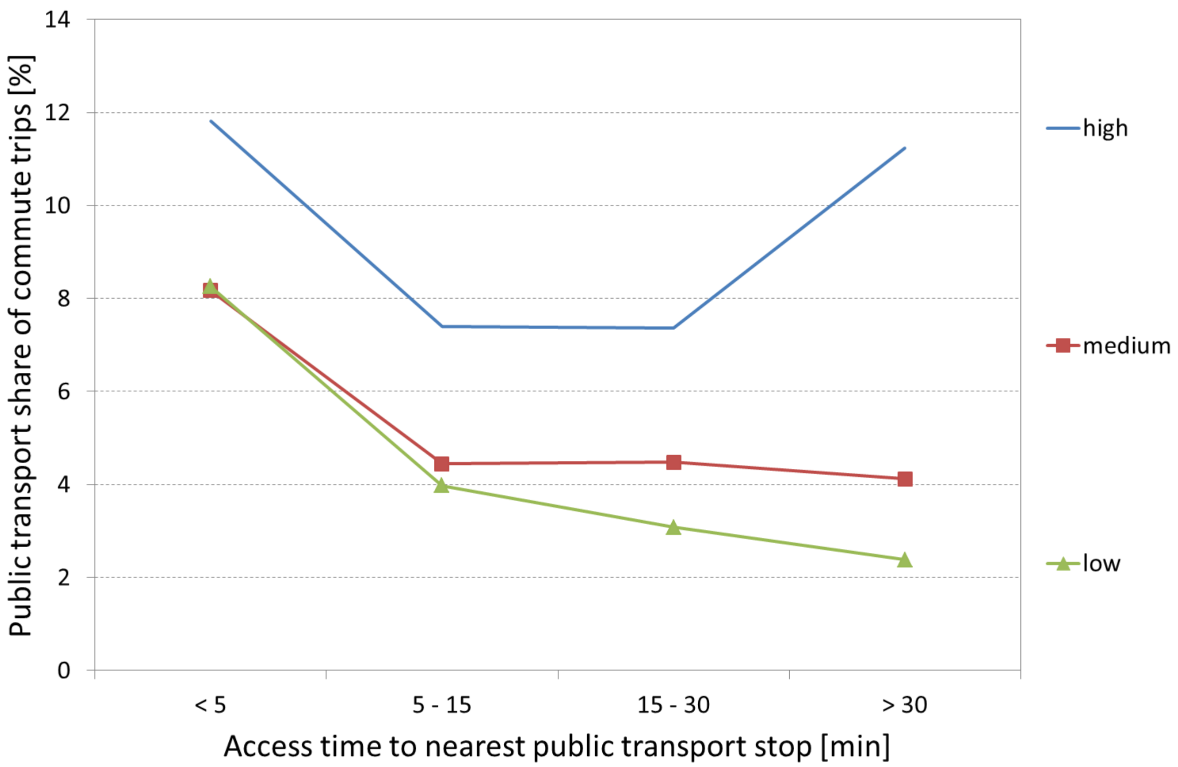


Figure 48 Public transport share in shopping trips, by distance to public transport stop and environmental concern cluster



7.4 Incentives to use public transport more

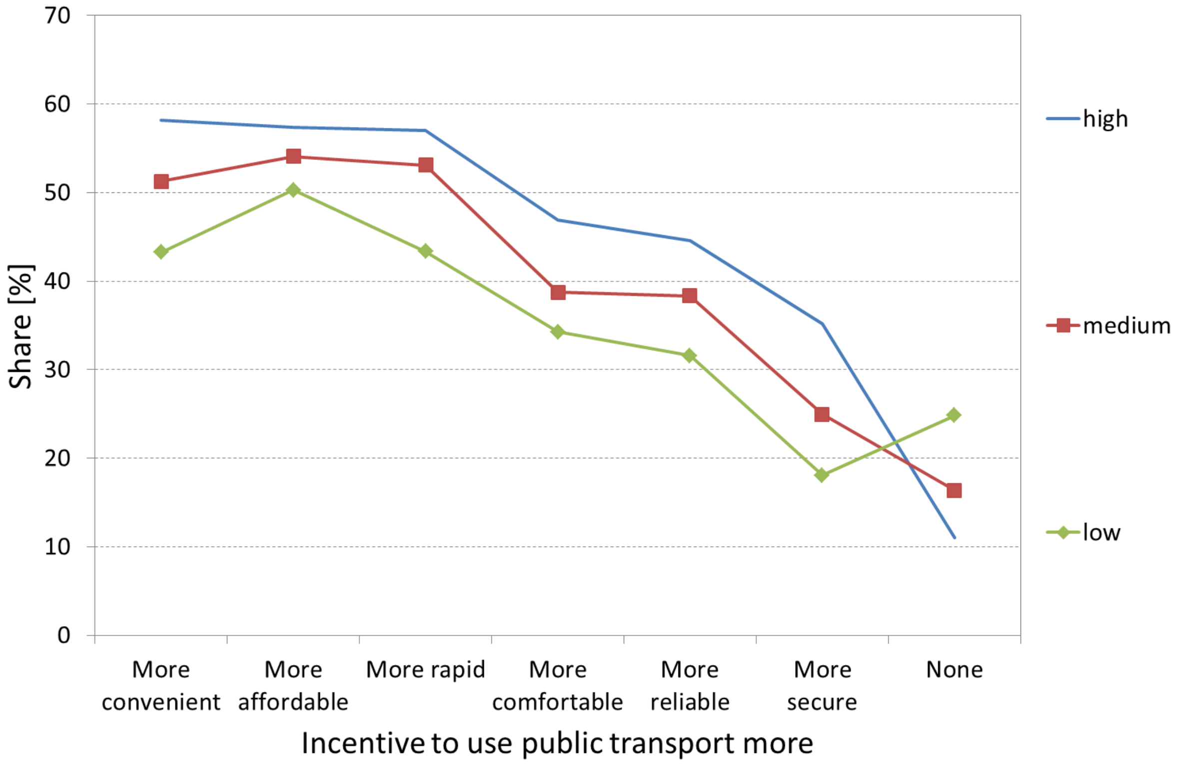
When attempting to encourage travellers to use their cars less, and to switch to alternative modes, it is important to know which policies could be applied to encourage such changes.

For the case of public transport, Figure 49 shows which share of the population from each environmental concern cluster would be encouraged to use public transport more by each given incentive.

The most important issues overall are convenience (probably related to the access time described above), cost and speed, all of which more than 50 per cent of people state as reasons for not using public transport more often. Of secondary importance are comfort and reliability, while security is surprisingly the least influential issue. In total, only 17 per cent of the respondents said that none of the incentives would lead them to travelling more by public transport; thus, there seems to be an overall willingness to switch transport mode, provided that the appropriate policies to deal with the main issues be put into place.

Overall, respondents belonging to the "high" environmental concern cluster would expectedly more quickly respond to any of the incentives than the others; this again hints at a greater willingness to adapt behaviour for highly environmentally aware persons.

Figure 49	Factors encouraging more public transport use, by environmental concern cluster



8 Summary and outlook

Various indicators of travel behaviour were used in the study that is presented here:

- Car ownership;
- car use;
- and mode choices for trips to frequently visited locations.

The analyses have shown that these indicators are heavily influenced by socio-economic characteristics of individuals, the spatial circumstances that they live in (and the inherent availability and quality of access to the desired destinations by slow modes and public transport), and, to a lesser extent, environmental attitudes and concerns. A summary of the main effects on car ownership and use is shown in Table 1.

A brief overview has been given of the potential of policy measures and government actions to reduce car use and encourage the use of alternative modes. Here, availability, affordability and speed of public transport were identified as the major drivers of a potential change in behaviour.

In terms of more detailed policy implications, the analysis presented here is too preliminary to lead to concrete recommendations. A thorough analysis of policies in place in the individual countries would have to be carried out in order to determine what possibilities are available at all. The models from the second stage of the study could then be used to assess the effects of such scenarios. However, a correct assessment of policy effects would evidently require a link to the spatial characteristics of the considered region: population structure, availability of job and other infrastructure, network models for private and public transport, etc.

As a very rough assessment though, from the data that has been analysed for this report, it appears that policies aiming at incentives for more environmentally friendly behaviour (rather that penalties for not doing so) are clearly preferred. Investments in public transport infrastructure are very popular and might lead to further shifts in modal shares, where significant improvements of that infrastructure is still possible. In the same vein, premiums for buying less-polluting cars would help as well. The underlying willingness to invest in such cars is present, as evidenced by the data on the willingness to pay additional costs for electric cars. However, the lack of infrastructure for using these vehicles still prevents many respondents from being willing to effectively carry out those investments.

Further work on the subject should focus on modelling travellers' behaviour in the context of:

- Discrete choice models of car ownership and mode choice for frequent trips;
- regression models for continuous demand variables, such as car use;
- and structural equations models for a correct representation of the relevant interaction effects between indicators.

The mode choice models will be limited by the available data – for example, no cost variables for the chosen and alternative modes were recorded. The alternatives are comparable via travel times only. This evidently limits the applicability of the data for the computation of key figures such as values of travel time savings (Hess *et al.*, 2008) or demand elasticities.

However, the models should provide a deeper insight into the significance of the effects discussed in the present report, when considered jointly rather than separately.

Table 1 Main effects of socio-economic and attitude variables on car ownership and use

Category	Level	Number of cars Per household	Per adult	Weekly distance driven [km]
-	Sample average	1.31	0.58	154.2
Country	Australia	1.66	0.78	155.8
	Canada	1.39	0.68	148.2
	Chile	0.94	0.35	160.9
	France	1.59	0.75	165.7
	Israel	1.24	0.53	210.6
	Japan	1.24	0.51	78.6
	Korea	1.17	0.44	121.8
	Netherlands	1.23	0.59	177.0
	Spain	1.46	0.60	150.3
	Sweden	1.21	0.66	138.1
	Switzerland	1.27	0.62	162.8
Gender	Male	1.32	0.58	187.7
	Female	1.29	0.58	113.9
Activity level	Student	1.24	0.44	96.8
	Working adult < 45	1.32	0.62	172.5
	Working adult > 45	1.43	0.61	186.6
	Homemaker	1.29	0.56	76.4
	Unemployed	1.12	0.51	124.8
	Unable to work	1.04	0.53	107.4
	Retired	1.25	0.62	111.3
Household size	1	0.71	0.71	142.6
	2	1.25	0.64	152.0
	3+	1.49	0.55	157.8
Area type of residential location	Major town/city	1.10	0.48	136.6
	Suburban	1.38	0.61	138.2
	Small town or village	1.50	0.69	176.3
	Isolated dwelling	1.81	0.88	222.1
Environmental concern cluster	high	1.24	0.53	146.3
	medium	1.34	0.60	153.7
	low	1.39	0.64	170.9

9 References

Bagley, M.N. and P.L. Mokhtarian (2002) The impact of residential neighborhood type on travel behavior: A structural equations modeling approach, *The Annals of Regional Science*, **36** (2), 279-297.

Cao, X., P.L. Mohktarian and S.L. Handy (2009) Examining the impacts of residential self-selection on travel behaviour: A focus on empirical findings, *Transport Reviews*, **29** (3) 359-395.

Dargay, J. and M. Hanly (2004) Land use and mobility, paper presented at the *10th World Conference on Transport Research*, Istanbul, July 2004.

Giuliano, G. and J. Dargay (2006) Car ownership, travel and land use: A comparison of the US and Great Britain, *Transportation Research Part A*, **40** (2) 106-124.

Hess, S., A. Erath and K.W. Axhausen (2008) Estimated value of savings in travel time in Switzerland: Analysis of pooled data, *Transportation Research Record*, **2082**, 43-55.

Mokhtarian, P.L. (2008) Examining the impacts of residential self-selection on travel behavior: A focus on methodologies, *Transportation Research B*, **42** (3), 204-228.

Ohmori, N. and N. Harata (2008) How different are activities while commuting by train? A case in Tokyo, *Tijdschrift voor Economische en Sociale Geografie*, **99** (5) 547-561.

Organisation for Economic Co-operation and Development (2011) *Greening Household Behaviour: The Role of Public Policy*, OECD, Paris.

Pucher, J. and L. Dijkstra (2003) Promoting safe walking and cycling to improve public health: Lessons from the Netherlands and Germany, *Public Health Matters*, **93** (9) 1509-1516.

Simma, A. and K.W. Axhausen (2004) Interactions between travel behaviour, accessibility and personal characteristics: The case of the Upper Austria region, *European Journal of Transport and Infrastructure Research*, **3** (2) 179-198.

The World Bank (2008) Motor vehicles per 1’000 people, http://data.worldbank.org/indicator/IS.VEH.NVEH.P3, retrieved October 31, 2011.

Weis, C. and K.W. Axhausen (2009) Induced travel demand: Evidence from a pseudo panel data based structural equations model, *Research in Transportation Economics*, **25** (1) 8-18.

Weis, C., K.W. Axhausen, R. Schlich and R. Zbinden (2010) Models of mode choice and mobility tool ownership beyond 2008 fuel prices, *Transportation Research Record*, **2157**, 86-94.

Weis, C., M. Vrtic, P. Widmer and K.W. Axhausen (2011) Influence of parking on location and mode choice: A stated choice survey, paper presented at the *91st Annual Meeting of the Transportation Research Board, Washington, D.C., January 2012.*

A 1 Analysis specific to Israel's national vehicle scrapping program

In the questionnaire, the respondents from Israel were asked about their knowledge and use of a national vehicle scrapping program that allows people to sell their vehicles to the state for about 3'000.- NIS (approximately 825.- US$). As can be seen in Figure 50, over 60 per cent of the respondents from Israel are aware of that program. Only a very small share has benefited from it though (2.4 per cent), and only 14.6 per cent intend to do so in the future.

Figure 50 Awareness of Israeli respondents of national vehicle scrapping program