Chapter 5

Personal Transport Choices

The transport sector is one of the major contributors to climate change. Personal transport also significantly contributes to local and regional air pollution with emission of pollutants such as nitrogen oxides and carbon monoxide. This chapter looks at the effects of different types of public policies influencing transport demand ranging from pricing measures, such as fuel taxes or financial incentives to buy "cleaner" vehicles, to car labelling or the provision of transport infrastructure. The main factors affecting car ownership, car use and car choice are analysed, as well as factors which encourage the use of public transport. The impact of the relative price of different means of transport on mode choice receives particular attention. The role of environmental "norms" on personal transport decisions is also considered, improving our understanding of how raising public awareness about the environmental effects of private car use can complement other policies.

1. Introduction

The transport sector is one of the major contributors to greenhouse gas emissions. The transport sector's contribution to climate change is around 20% of total emissions in countries which form part of the United Nations Framework Convention on Climate Change (UNFCCC).[1] Moreover, in 15 EU countries greenhouse gas emissions have been decreasing in recent years in all main sectors, with the exception of transport. In fact, from 1990 to 2006 they grew by 26% of which 90% were due to road transport (EEA, 2008). According to Stern (2007) "CO_2 emissions from transport are expected to more than double in the period to 2050", one of the fastest growing sectors.

Personal transport is also a significant contributor to local and regional air pollutants. Indeed, road traffic is the single most important source of nitrogen oxides, benzene and carbon monoxide in many countries. Lead emissions are decreasing in importance, but emissions of particulate matter (PM) are of increasing concern, and some of the health effects are summarised below. Secondary pollutants, such as nitrogen oxides and volatile organic compounds (VOCs) are also of concern, since they lead to the formation of tropospheric ozone (O_3).

While other transport modes (*e.g.* public transport) are not environmentally-benign, the impacts of personal car use per kilometre travelled, are by far the greatest. The environmental impacts of car use can be reduced by:

- reducing the number of vehicle kilometres driven and car-sharing;
- switching from car use to other transport modes which are less damaging;
- installing pollution control devices and improving combustion characteristics for petrol and diesel vehicles; and
- using alternative-fuelled vehicles (*e.g.* electric or hybrid vehicles).

To one extent or another the OECD project on "Environmental Policy and Household Behaviour" examined three of these four channels – with the third being the exception by looking at the policy, demographic and economic factors which affect people's decisions to adopt personal transport behaviour

Table 5.1. **Short-term and long-term effects of personal transport**

Pollutant	Short-term effects	Long-term effects
PM	• Increase in mortality. • Increase in hospital admissions. • Exacerbation of symptoms and increased use of therapy in asthma. • Cardiovascular effects. • Lung inflammatory reactions.	• Increase in lower respiratory symptoms. • Reduction in lung function in children and adults. • Increase in chronic obstructive pulmonary disease. • Increase in cardiopulmonary mortality and lung cancer. • Diabetes effects. • Increased risk for myocardial infarction. • Endothelial and vascular dysfunction. • Development of atherosclerosis.
O_3	• Increase in mortality. • Increase in hospital admissions. • Effects on pulmonary function. • Lung inflammatory reactions. • Respiratory symptoms. • Cardiovascular system effects.	• Reduced lung function. • Development of atherosclerosis. • Development of asthma. • Reduction in life expectancy.
NO_2	• Effects on pulmonary structure and function (asthmatics). • Increase in allergic inflammatory reactions. • Increase in hospital admissions. • Increase in mortality.	• Reduction in lung function. • Increased probability of respiratory symptoms. • Reproductive effects.

Source: Adapted from WHO (2004b, 2006).

which is more or less environmentally-damaging. There are three significant benefits of the project with respect to previous work in this area:

- Data have been collected across ten countries, allowing for significant variation in those demographic, socio-economic, spatial, and policy characteristics which are likely to affect mode choice.
- Data have been collected by mode (car, public transport, cycle, etc.) and travel purpose (commuting, shopping, etc.). Since different factors may affect mode choice for different travel purposes this is important.
- Data have been collected on both the "push" (*i.e.* fuel prices) and "pull" factors (*i.e.* transport infrastructure) which are likely to affect mode choice.
- Since the project as a whole covers a number of thematic areas, we are able to examine the role of environmental "norms" on personal transport decisions, an issue which has rarely been addressed empirically.

This chapter is based upon the report prepared for the OECD by Alejandro Guevara-Sangines and José Alberto Lara-Pulido (Universidad Iberoamericana, Mexico) on "Mode choice and public transport use" and the report prepared by Clotilde Bureau (formerly ENSAE), Nick Johnstone and Ysé Serret (OECD Secretariat) on "Car ownership and car use". The full technical reports are available at: *http://dx.doi.org/10.1787/9789264096875-en* and *www.oecd.org/environment/households/greeningbehaviour*.

Before proceeding to a discussion of the results of the OECD project the following section provides a brief literature review of previous work in this area. It is important to note that almost all of these studies cover a single country, and only a sub-set of the variables used in the OECD project. However, most draw upon "panel" data rather than a single cross-section which has important advantages for the analysis of certain personal transport decisions.

2. Literature review

Research on personal transport decisions has been focused on analysing the impact of several variables on households' transport choices. In this context, most studies try to explain households' decisions on transport mode choice, car ownership, and their use. However, there is a relatively small number of previous studies which examine decisions related to public transport, usually in terms of a substitute for car travel. Table 5.2 provides a summary table of the results.

The results show that, in general, the effects of economic and demographic variables are consistent with expectations. However, it is interesting to note that for many variables (*e.g.* income, age, gender) the signs are opposite for car ownership use and public transport use. With respect to the effect of city size and density this is also true, reflecting the economies of scale and density of public transport service provision.

As will be seen, the results of the work arising out of the OECD project are consistent with the results in the literature. However, there are three points to bear in mind:

- Relatively few studies look at the role of accessibility to public transport and attitudes toward the environment.
- Data coverage with respect to explanatory variables is often quite limited, particularly in the case of public transport.
- Moreover, the studies do not look at potential substitution with other modes (*e.g.* cycling or walking).

Before proceeding to a summary of the empirical results based on the OECD survey, the following sections provide some descriptive data on mode choice, car ownership and public transport use.

3. Mode choice

Figure 5.1 presents data on the aggregate figures for mode choice for four travel purposes (commuting, shopping, education, and visiting family and friends) for the full sample of responses from all ten countries. It is important to distinguish by travel purpose since quite different policy incentives may be needed in different cases. For instance, encouraging changes in mode choice for

Table 5.2. **Summary of results of previous studies**

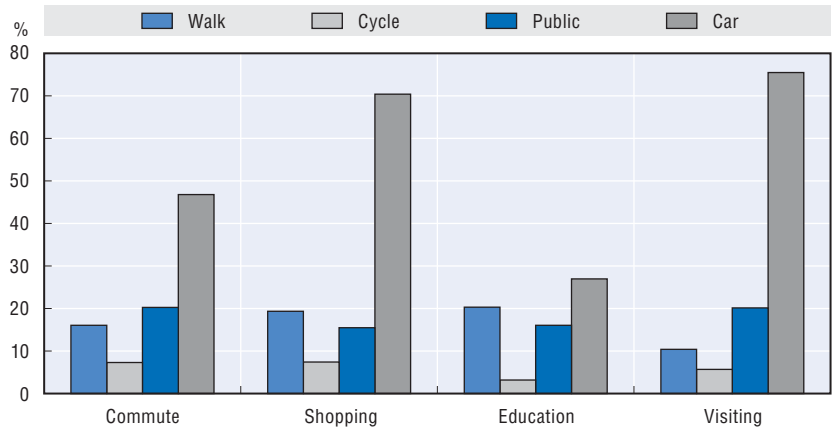
Independent variable	Income	Age	Male	Education	HH size	Working (# No.)	Children (# No.)	Density/near CBD	Accesibility to public transport	Attitude to environment	Country
Car ownership											
Train (1980)	+				+			–			United States
Bhat and Koppelman (1993)	+			–			– #				Netherlands
Asensio *et al.* (2002)	+	+/–		+	+	+#					Spain
Dargay (2005a)	+	–	+		+	+	+ 0 –				EU14
Simma and Axhausen (2004)			+				– #		–		Austria
Abreu e Silva *et al.* (2006)	+	–	+		+	+ #		–			Portugal
Giuliano and Dargay (2006)	+	–			+		+	–	–		United States/ United Kingdom
Nolan (2002)	+	+	+	+	+	+	+#				Ireland
OECD Survey	**+**	**+**	**+**	**0**	**+**	**+**	**+**	**+**	**–**	**–**	**OECD10**
Car use											
De Jong (1996)	+	–	+	+		+					Netherlands
Abreu e Silva *et al.* (2006)	+	–	+		+	+		–			Portugal
Feng *et al.* (2005)	+	–	+	+	+	+/#	+#				United States
Fullerton *et al.* (2005)	+	–		–	0	+/–	+				Japan
Steg *et al.* (2001)	+	+/–	+	+	–		–			–	Netherlands
Johansson-Stenman (2002)	+	+	+								Sweden
Dargay and Hanly (2004)	+	+/–	+		+	+		–	–		United Kingdom
Asensio *et al.* (2000)	+	+/–		+	+	+#					Spain
Nolan (2002)	+	0	+	0	+	+	+				Ireland
Simma and Axhausen (2004)			+				– #		–		Austria
Golob and Hensher (1998)	?	+	+/–	–	–					–	Australia
Dargay (2005)	+		0		+	– (F) #	+ (F)	–			United Kingdom
OECD Survey	**+**	**+/–**	**+**	**0**	**+**	**+**	**0**	**–**	**+**	**–**	**OECD10**

Table 5.2. **Summary of results of previous studies** *(cont.)*

Independent variable	Income	Age	Male	Education	HH size	Working (# No.)	Children (# No.)	Density/near CBD	Accesibility to public transport	Attitude to environment	Country
Public transport use											
Abreu e Silva *et al.* (2006)	–	+	–								Portugal
Johansson-Stenman (2002)	–	–/+	–	+			–			0	Sweden
Golob and Hensher (1998)	+	–/+	–	– +/						+	Australia
Dieleman *et al.* (2002)	–			–			–				Netherlands
OECD Survey	**–**	**–/+**	**0**	**+**	**0**	**–**	**–**	**+**	**+**	**+**	**OECD10**

Source: OECD (2008b), *Household Behaviour and the Environment: Reviewing the Evidence*, OECD, Paris.

Figure 5.1. **Mode choice by travel purpose (full sample)**



Source: OECD Project on Household Behaviour and Environmental Policy.

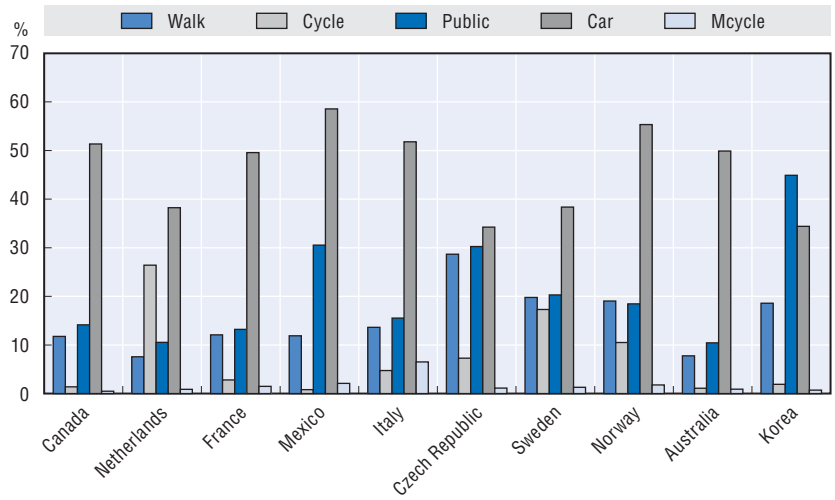
habitual (*e.g.* commuting to and from work) and episodic (*e.g.* visiting family and friends) travel may require different policy levers. Similarly, encouraging change in mode choice for travel purposes which are more "cumbersome" (*e.g.* shopping) is often linked with cultural habits and land use patterns.

Car travel is the most common mode for all travel purposes except education. Car travel is used intensively for "visiting friends and family". It is notable that cars are the most common mode for shopping, with 70% responding that they use this mode regularly. The use of public transport is relatively uniform across different travel purposes.

Are there differences across countries? Due to its relative importance in total travel, Figure 5.2 gives the percentages for commuting to and from work disaggregated by country. The use of the car is the most common mode in all countries except Korea, where public transport is most common. Australia is the country with the greatest share of trips made by car, and with one of the smallest shares of trips by bicycle. Public transport comes second in most countries. Cycling to and from work is much more common in the Netherlands (and to a lesser extent Sweden and Norway) than elsewhere.

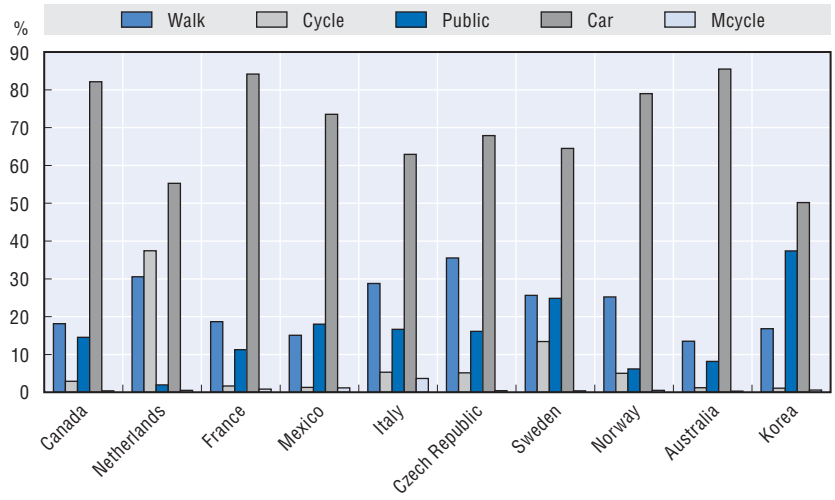
Figure 5.3 provides the same information for shopping, a travel purpose for which significant efforts in a number of OECD countries have been made to bring about changes in mode choice (*i.e.* restrictions on out-of-town shopping centres). However, even more than is the case for commuting, travelling to shopping facilities is done most frequently by car. Walking is relatively common, often ranking second in importance (Canada, France, Italy, the Czech Republic, Sweden, Norway) ahead of public transport. Once again, cycling is common in the Netherlands, and to a lesser extent Sweden. Empirical work

Figure 5.2. **Mode choice for commuting by country**



Source: OECD Project on Household Behaviour and Environmental Policy.

Figure 5.3. **Mode choice for shopping by country**



Source: OECD Project on Household Behaviour and Environmental Policy.

indicates that spatial characteristics and environmental concern are important factors in this choice. However, even taking such factors into account, there is important "residual" variation which is explained by the country in question, and thus perhaps attributable to cultural characteristics and cycling infrastructure. Data provided below confirm the importance of the latter point.

In general, the share of trips associated with educational activities is more evenly distributed across different modes. The pattern of trips for sporting and cultural activities (not reported) indicates that an important proportion of trips for these purposes are made by modes other than the car. However, at least in the former case (sports) this could indicate that walking and cycling are considered as an activity in and of itself, rather than a mode of transport.

With some exceptions, the overall picture that emerges is that car travel is the most common mode, and that public transport and walking are the second most common choices, having similar shares in several cases. However, in the case of commuting, empirical work has shown that the choice between these two is largely a function of distance travelled. Cycling is the least commonly used travel mode option. However, it is the area in which variation is the greatest, and thus potentially one in which increased use can be induced.

Despite these generalities, differences by country are significant. For example, in South Korea a very different pattern is observed: the importance of trips by public transport is the same or greater than the importance of car trips. Only in the Netherlands, Sweden, the Czech Republic and Norway does cycling appear to be an even moderately important mode of transport.

4. Car ownership, choice and use

Car ownership is a "discrete" decision, and one which has significant influence on all subsequent choices of mode for different travel purposes. The decision not to own a car can be seen as a decision to restrict mode choice. This is not true of other modes (except perhaps cycling in the absence of a public services such as Velib). As such, it is important to look at the decision to own (and use) a car in some detail.

Respondents were asked to report the number of cars their household owned. In total, 13.7% of the respondents reported having no car, 46.1% one car, and 31.6% two cars. Very few households reported having more than two cars. The mean number of cars in the different country samples is presented in Table 5.3 below. (For corroboration of this data see *www.oecd.org/environment/households*.)

Those households that did not own a car were requested to indicate the primary reason why they did not do so. Figure 5.4 summarises the responses. As expected, affordability is the main factor, but it is revealing that "environmental" concerns rank so low. Indeed, there is little correlation between respondents' declared concern for the environment and car ownership, indicating that if this factor plays a role it is relatively less important than the other factors (*e.g.* income) which are likely to affect car ownership.

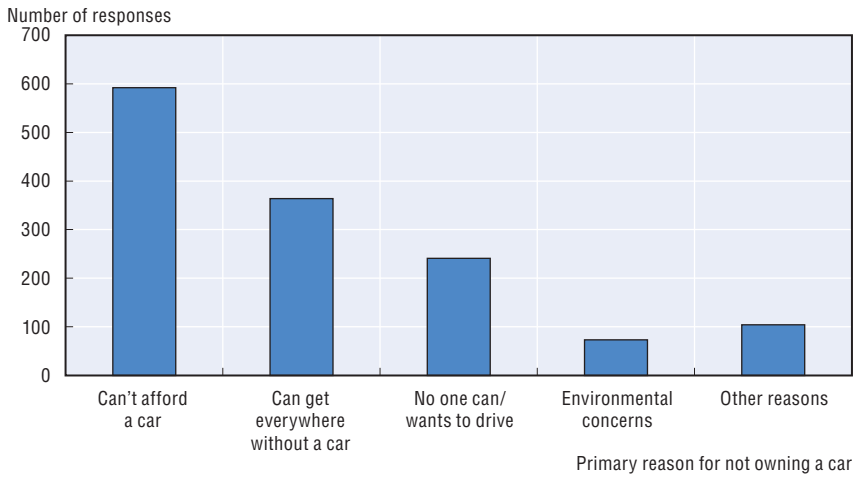
Alternative car technologies such as hybrid, electric and (in some cases) biofuel vehicles are a potential means of reducing greenhouse gas emissions and emission of local air pollutants. In the survey, respondents were

Table 5.3. **Mean number of cars per household and per household member**

	Mean per household	Standard deviation	Mean per capita	Standard deviation	Observations
Canada	2.424	.910	.711	.267	984
Netherlands	1.997	.730	.656	.265	1 010
France	2.505	.794	.756	.278	1 055
Mexico	2.558	1.040	.590	.303	969
Italy	2.720	.861	.715	.249	1 397
Czech Republic	2.226	.892	.598	.264	694
Sweden	1.985	.847	.654	.308	987
Norway	2.410	.873	.733	.304	985
Australia	2.629	.931	.731	.264	986
Korea	2.152	.705	.489	.200	963

Note: Standard deviation shows how much variation or "dispersion" there is from the *mean*.
Source: OECD Project on Household Behaviour and Environmental Policy.

Figure 5.4. **Stated reasons for not owning a car**



Source: OECD Project on Household Behaviour and Environmental Policy.

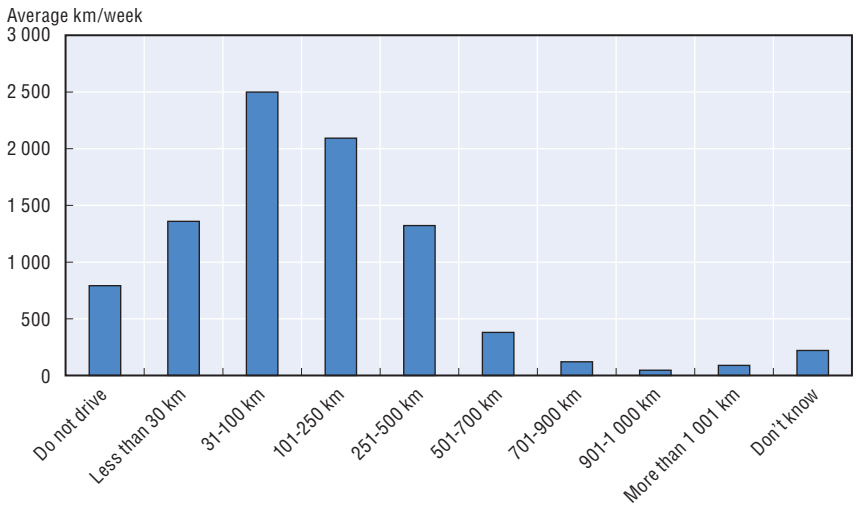
requested to provide information on the fuel type of their vehicle. The percentage of respondents in the total sample who reported having an alternative fuel car as their main car is very small (less than 6%), and it mainly corresponds to people owning a LPG (liquefied petroleum gas) car (87%).

While these results may suggest that market penetration of such types of vehicles is still limited, it could also be due to the fact that alternative fuel vehicles may be used as a second car rather than as a main car. Indeed, the average number of cars owned is higher for people owning hybrid vehicles. In addition, people having LPG or hybrid vehicles are more concentrated in

suburban and urban areas. One could assume that infrastructure associated with alternative fuel vehicles is more developed in more concentrated areas. There are also more people in the highest income decile in the sub-sample of people owning a hybrid vehicle than for people having a conventional fuel vehicle. Finally, membership of an environmental organisation is positively correlated with the ownership of an alternative fuel vehicle. As market penetration increases it will be possible to look at these issues in greater depth.

For car owners, mean weekly (personal) driving distances are given in Figure 5.5 below. There is a negative correlation between the index of environmental attitudes on the one hand, and both car ownership and average weekly kilometers driven amongst car-owning households on the other hand. The importance of such attitudes relative to economic, demographic and policy factors is discussed below.

Figure 5.5. **Number of kilometres driven per week by respondents in car-owning households**



Source: OECD Project on Household Behaviour and Environmental Policy.

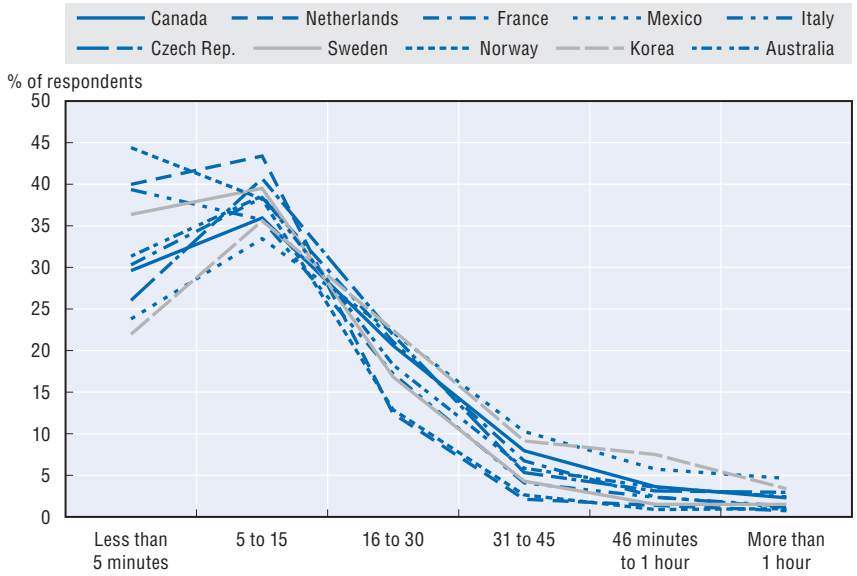
5. Public transport accessibility and use

In order to bring about less environmentally-damaging personal transport patterns, one of the greatest challenges is to encourage the substitution of car travel for public transport. In order to understand what motivates people to use (or not use) public transport, data were collected on accessibility. Specifically, respondents were requested to indicate "how far is your primary residence from the public transport/station which is most convenient for your daily commute?"

Respondents could indicate whether it was: less than five minutes; 5 to 15 minutes; 16 to 30 minutes; 31 to 45 minutes; 46 minutes to an hour; and over 1 hour.

Differences across countries can be seen in Figure 5.6 below. Since responses for urban and rural households are likely to differ to such a great extent, the figure only includes "urban" households. Much of the variation can be seen with respect to those who live less than 15 minutes from the most convenient stop. The Netherlands and Norway stand out, followed by France and Italy. At the other extreme are Mexico and Australia.

Figure 5.6. **Distance (in minutes) to most convenient public transport stop**

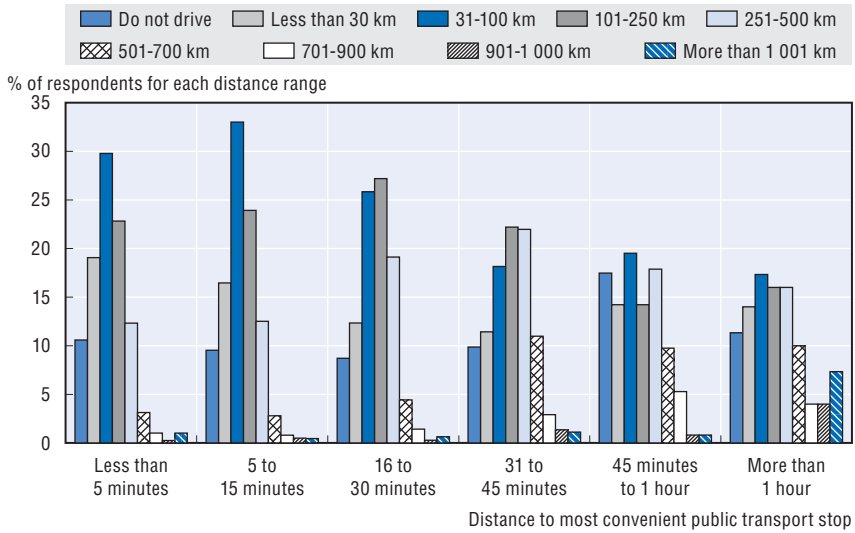


Source: OECD Project on Household Behaviour and Environmental Policy.

The relationship between access to a public transport stop and average driving distance is given in Figure 5.7. There is a marked tendency for respondents with less convenient access to public transport to drive more than others. However, this difference only appears to become particularly marked once public transport becomes very inconvenient (> 30 minutes). The mean weekly driving distance for households is 126 kilometres for households within 15 minutes of a public transport stop, rising to 163 kilometres for those in the range 15-30 minutes, and 225 kilometres for those greater than 30 minutes.

The empirical results reported below indicate that there is a significant difference between the effect of being within 5 and 15 minutes of a public transport stop in terms of car ownership and use. Moreover, above fifteen

Figure 5.7. **Convenience of access (minutes) to public transport and weekly vehicle kilometres driven**



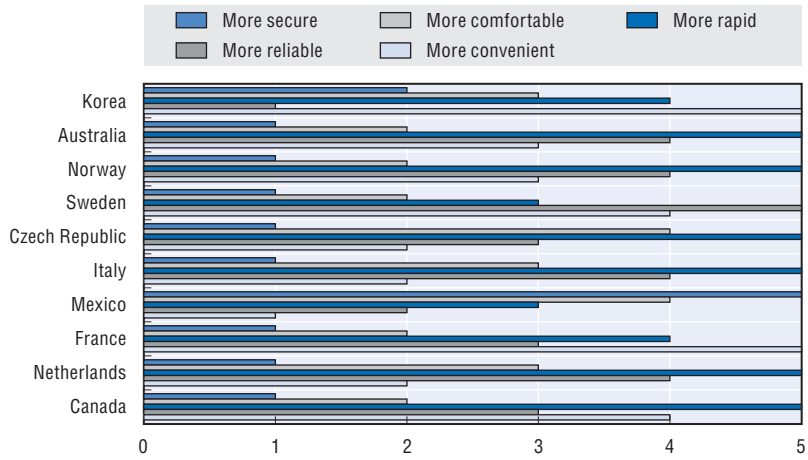
Source: OECD Project on Household Behaviour and Environmental Policy.

minutes there is no discernible impact. However, convenience of access is only one attribute of public transport amongst many and it is therefore necessary to determine precisely those factors which are likely to induce greater use of public transport if policy makers are to encourage mode switching. In Figure 5.8 the average ranking of the effect of different aspects of public transport are given. Rapidity is an important factor in most countries. However, in some countries other factors are more important – *i.e.* personal security in Mexico, reliability in Sweden and convenience in France. Significantly, for all ten countries personal security is ranked (on average) higher by women than men.

In addition to public transport, cycling is of course a potential substitute for personal car travel. Figure 5.9 presents the relationship between the frequency of cycling as a travel mode for different travel purposes and the percentage of respondents that stated that "more and better cycle paths" would encourage them to travel by car less often. There is a pronounced negative relationship (correlation = –0.54) indicating that those countries in which cycling is not common would see significant increase in the choice of this mode with greater investment in cycling infrastructure. As expected, this relationship is even stronger for the urban population (correlation = –0.60).

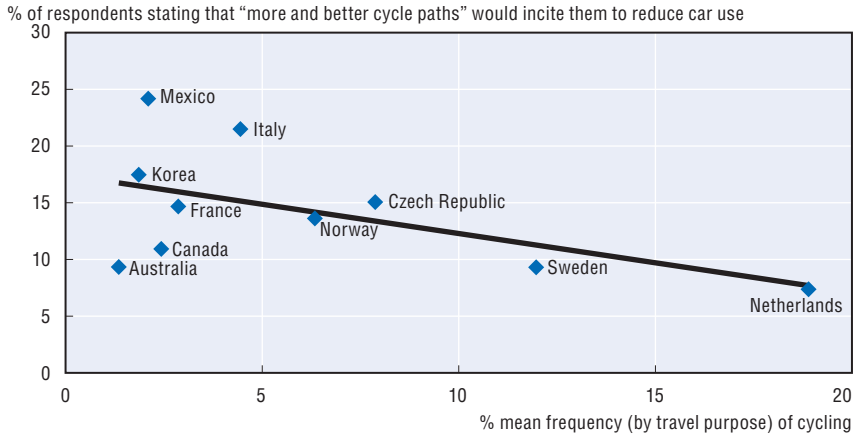
Figure 5.8. **Influence of improvements in public transport on increasing use**

1 = least important and 5 = most important



Source: OECD Project on Household Behaviour and Environmental Policy.

Figure 5.9. **Cycling infrastructure and frequency of use**



Source: OECD Project on Household Behaviour and Environmental Policy.

6. The determinants of mode choice

Car ownership and use

What factors are encouraging households to own and use their cars? While the correlations presented in Sections 3 and 4 indicate that environmental attitudes and access to public transport have an impact on car ownership and use, the empirical evidence indicates that a large number of other factors are at play. For instance, based upon a review of previous literature in this area

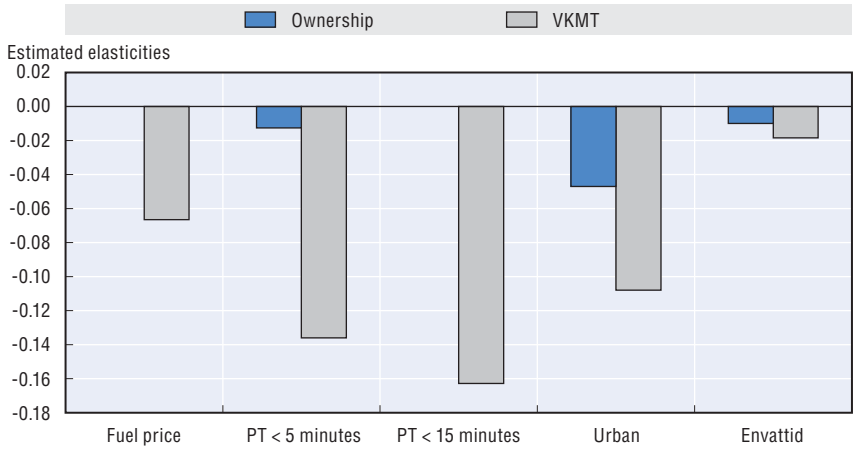
(summarised above), a number of economic and demographic variables are important, including income, operating costs of the vehicle, age of the respondent, household size and composition (*e.g.* number of children), location of residence, and employment status.

Given the large number of factors involved, econometric models are required to try and answer this question. In order to obtain reliable results, the two decisions (ownership and use) were estimated together.[2] The results are largely consistent with the existing literature and expectations.

Income has a positive and significant effect on both car ownership and driving distance,[3] as does employment (whether full-time or part-time). In terms of demographics, men are more likely to own cars, and to drive greater distances. Car ownership increases with age, but the sign on the square of age is negative and significant, suggesting that the effect of age decreases after a certain point. The relationship between age and car use is the same. Residing in an urban area decreases ownership and use, as expected. And finally, having children five years of age or less in the household increases the likelihood of car ownership.

Figure 5.10 summarises the results for the main variables of more policy-relevance. The results are expressed in terms of elasticities. Firstly, the proxy variable for fuel price has the expected negative effect on driving distance, although the effect is relatively small.[4] This supports more descriptive evidence in which respondents indicated that on average a 20% increase in fuel prices would reduce their consumption by approximately 7%-8%.

Figure 5.10. **Effects of fuel prices, transport accessibility and environmental attitudes on car ownership and use**



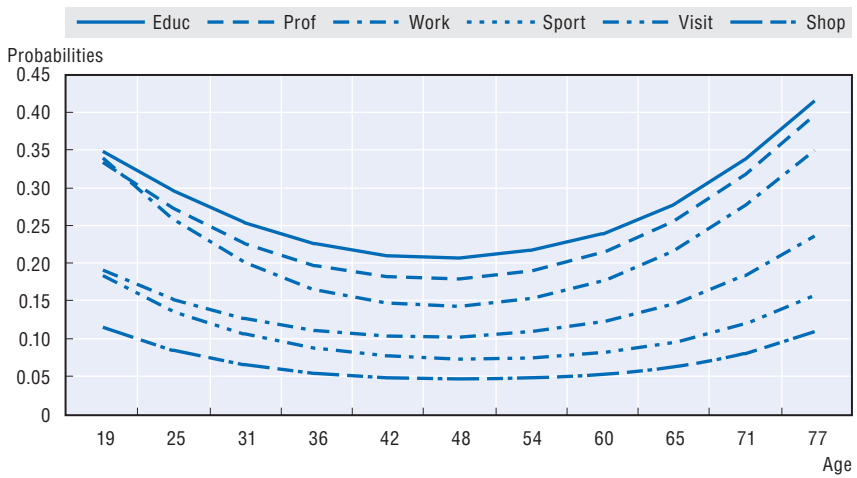
Source: OECD Project on Household Behaviour and Environmental Policy.

The index variable reflecting "environmental norms" has a negative effect on car ownership, but not on driving distance (the coefficient is insignificant) – *i.e.* environmental norms affect the decision to own a car, but not the use of the car if there is one in the household. Another interesting result relates to the effect of access to public transport, with a negative and significant sign on car use if the household lives within either 5 or 15 minutes of a public transport stop. However, for ownership the effect only holds if the household lives within five minutes of a public transport stop.

Since increased use of public transport is likely to be the most effective way to reduce the environmental impacts associated with personal car use, it is interesting to note that 35% of respondents state that they would drive their cars less if public transport was cheaper. However, the likely magnitude of such a response was examined in more detail through the use of a set of more sophisticated models[5] which estimated mode choice for the different travel purposes.

The effect of income on the odds of commuting by public transport relative to commuting by car is negative. That is to say, as income rises, there are less chances of choosing public transport. The predicted probabilities when travelling to undertake professional or educational activities are the highest. In contrast, when shopping, these probabilities are the lowest. With respect to age, a life-cycle effect is found.[6] Younger and older people have higher probabilities of commuting by public transport than middle-aged ones. For all destinations the minimum probability of choosing public transport is at the age of 48 years old, approximately (see Figure 5.11).

Figure 5.11. **Age (predicted probabilities of commuting by public transport)**



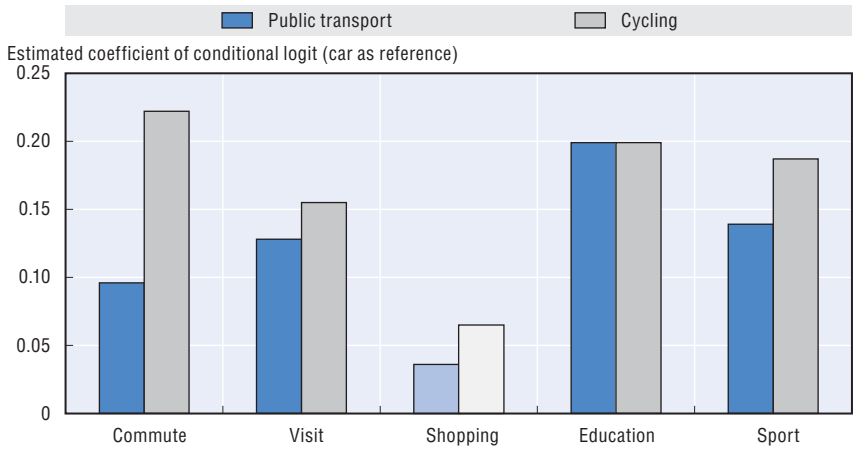
Source: OECD Project on Household Behaviour and Environmental Policy.

For almost all travel purposes the number of adults in the household has a weak effect on mode choice, with the exception of educational activities. There is not a statistically significant difference between females and males in terms of mode choice. The number of children decreases the probability of choosing public transport; however, a significant effect is only found when travelling to accomplish educational activities and when visiting family and friends.

Our findings are consistent with past studies that indicate that people in urban municipalities and/or not living in detached houses have greater odds to use public transport relative to commuting by car. The effect of a dummy variable which is equal to one when there is not a public transport station in reasonable proximity to the residence indicates that instead of walking or cycling people prefer to commute by car. The effect is greatest for shopping and commuting – indicating that these "habitual" travel purposes are most affected by the absence of accessible public transport.

The index of environmental attitudes was also included in the models. Environmental norms do have an influence on mode choice for commuting to and from work, educational activities, and leisure activities (sport and visiting family and friends). The stronger the norms the greater the probability that public transport or cycling will be chosen over car travel. The effect on cycling is greater than the effect on public transport for commuting, visiting family and friends and sporting activities (see Figure 5.12). It is interesting that mode choice for shopping is not affected by environmental norms (the bars are in light to reflect the statistical insignificance of the variables).

Figure 5.12. **Effect of environmental norms on mode choice (relative to car travel)**



Source: OECD Project on Household Behaviour and Environmental Policy.

To capture "fixed" effects by country a set of dummies were included in estimations. Thus, taking into account all differences between countries and respondents (*i.e.* spatial characteristics, economic factors, etc.) there are still country-specific effects which indicate that:

- Respondents in the Czech Republic and France have the largest probabilities of travel by foot (with the exception when destination is shopping).
- Respondents in Mexico have the highest probabilities of commuting by car for five of six travel purposes (with the exception of sports and cultural activities).
- Respondents in South Korea have the highest probabilities of commuting by public transport independently of travel purpose.
- Respondents in the Netherlands reflect the highest probabilities of cycling independent of travel purpose.

Another systematic difference is found with respect to regional effects. In general, willingness to commute by foot or by public transport is greatest in: New South Wales and Victoria (Australia), Ontario and Quebec (Canada), Ile de France (France), North West and South regions (Italy), North-west region and Prague (the Czech Republic), Federal District and State of Mexico (Mexico), Oslo (Norway), and Gavleborg and Gotland (Sweden). With these results, it seems that regional differences come mainly from accessibility to public transport and the size of the municipality.

7. Conclusions and policy implications

This study has sought to cast further light on the determinants of personal transport choices. In particular, data were collected on mode choice, car ownership, fuel choice, public transport accessibility and a number of other relevant factors.

While the OECD collected some data on the ownership of alternative-fuelled vehicles, ownership is not sufficient to draw any firm conclusions on the factors which increase penetration. Moreover, since much of environmental policy with respect to personal transport has focussed on the use of incentives (pricing, regulatory, information) to encourage substitution from personal car use to public transport this chapter has primarily summarised the work undertaken in this area.

It is clear that demographic (*e.g.* age, gender, household composition) economic (*e.g.* income, employment status) and structural factors (*e.g.* location of residence) affect the choice between these two modes. These factors can be considered exogenous – and thus not subject to direct influence through environmental policy. However, an understanding of their role is important in assessing the likely impacts of different policies on personal transport choices. Moreover, in the longer term some of these factors – *e.g.* location of residence in relation to destination for different travel purposes – are subject

to policy influence. Efforts to discourage out-of-town shopping and urban sprawl can be seen in this light, and the results of the OECD project indicate that they will reduce car use significantly.

From a policy perspective it is hardly surprising to find that the relative price of different modes has an influence on mode choice. While the variable used in the empirical work to reflect the relative cost of car use is far from ideal, the results confirm that changing the relative cost of the two modes will influence personal transport choices. This result is supported by the stated responses of respondents to the survey with respect to a number of questions. For instance, 35% of respondents indicated that they would drive their cars less if public transport was cheaper. Similarly, respondents indicated that on average a 20% increase in fuel prices would reduce their consumption by approximately 7%-8%.

While prices matter, given the nature of personal transport decisions they may not suffice. In order to be discouraged from using the car, it is important that there be a substitute mode available. The results indicate clearly that improving the accessibility of public transport will reduce car ownership and use, and encourage the use of public transport. However, "accessibility" needs to be carefully defined – above 15 minutes there is no discernible impact, and below five minutes the impact on car use is considerably greater.

More generally, public transport service quality is likely to decrease car use and increase public transport use. While rapidity and convenience are cited as being important additional factors in all countries, the other factors which also matter differ by country – *i.e.* personal security in Mexico, comfort in the Czech Republic. Improved reliability is important in Sweden, but not at all in Korea. This is instructive for policy design – the factors which will encourage people to use public transport vary by country.

In addition, a better cycling infrastructure is also likely to reduce car use, particularly in those countries where use of this mode is limited at present. Given the relative costs associated with developing a cycling infrastructure this may be a relatively efficient policy option in those countries in which the frequency of use of this mode is limited at present (*e.g.* Mexico, Korea, Australia). However, the results indicate that substitution possibilities vary greatly by travel purpose. Shopping seems to pose a particular challenge for obvious logistical reasons. However, the extent of variation across countries is instructive, and indicates that significant substitution can be encouraged in some countries.

Above and beyond the effects of factors such as price and infrastructure, it is clear that the attitude of respondents toward environmental issues has an effect on personal transport decisions. This effect is stronger with respect to car ownership than use, indicating that concern for the environment has a

greater impact on "discrete" choices. The effect of environmental "norms" also varies by travel purpose. They do affect travel for commuting and educational purposes. These results indicate that a soft policy effectively influencing people's beliefs and attitudes to the environment would have a positive impact on substituting their car for an alternative mode.

Overall the results indicate the importance of looking at mode choice and travel purpose together. In addition, it can be concluded that a mix of push-pull instruments is required in order to encourage transport choices which are less environmentally-damaging. Increasing the cost of driving and accessibility to public transport must go hand-in-hand. Furthermore, a combination of "hard" policies (*e.g.* taxes and regulations) and "soft" policies (*i.e.* which inform people's attitudes) is required to induce mode switching. And finally, some policies will have a greater impact on decisions which relate to discrete decisions (*e.g.* car ownership), while others will have a greater impact on everyday decisions (*e.g.* mode choice for a particular travel purpose).

Notes

1. These countries are those included in "Annex 1" of the Convention, which include the industrialised countries that were members of the OECD in 1992, and some countries with economies in transition, including the Russian Federation, the Baltic States, and several Central and Eastern European States.
2. Specifically, a selection equation is estimated, in which a probit model is estimated to determine car ownership. The results of this are then used to estimate driving distance using ordinary least squares.
3. Respondents were requested to report their combined annual household after-tax income with respect to twelve different income brackets, differentiated by country. This was transformed into a continuous variable by taking the mid-point of the ten intermediate ranges. The values for the bottom and top brackets were determined by fitting a polynomial. The values were then converted into euros on the basis of nominal exchange rates, giving 120 potential values (10 countries by 12 brackets).
4. This is not strictly a fuel price elasticity since data was not collected on actual prices paid. Respondents reported their monthly expenditures on fuel, and a proxy for the fuel price was obtained by dividing fuel expenditures by monthly vehicle kilometres driven. However, since this value will also reflect a number of factors which are not accounted for (*e.g.* vehicle fuel efficiency, driving conditions, etc.), the estimated coefficients of this variable should not be interpreted as fuel price elasticities.
5. Specifically, conditional logit models were estimated, which allows for the substitution between modes to be tested directly.
6. This approach permits us to observe both marginal effects and predicted probabilities. When a coefficient is not significant it is indicated by a dashed line/bar. Probabilities were predicted for all values that a certain variable can take and fixing all other variables at their mean. In the case of dichotomous variables the change on predicted probability is presented instead of probabilities. Also, fixed effects by country are presented with predicted probability for each destination.

References

Abreu e Silva, J. de, T.F. Golob and K.G. Goulias (2006), "The Effects of Land Use Characteristics on Residence Location and Travel Behavior of Urban Adult Workers", paper presented at the 85th Transport Research Board Annual Meeting, Washington DC.

Asensio, J., A. Matas and J.L. Raymond (2002), "Petrol Expenditure and Redistributive Effects of its Taxation in Spain", *Transportation Research Part A*, Vol. 37, pp. 49-69.

Bhat, C.R. and F.S. Koppelman (1993), "An Endogenous Switching Simultaneous Equation System of Employment, Income and Car Ownership", *Transportation Research Part A*, Vol. 27(5), pp. 49-69.

Dargay, J. (2005), "L'automobile en Europe : Changement de comportements d'équipement et d'usage", *Étude spécifique britannique*, final report to ADEME, August.

Dargay, J. and M. Hanly (2004), "Land Use and Mobility", Proceedings of the World Conference on Transport Research, Istanbul, Turkey.

de Jong, G. (1996), "A Disaggregate Model System of Vehicle Holding Duration, Type Choice and Use", *Transportation Research Part B*, Vol. 30(4), pp. 245-324.

Dieleman, F., M. Dijst and G. Burghouwt (2002), "Urban Form and Travel Behaviour: Micro-level Household Attributes and Residential Context", *Urban Studies*, Vol. 39(3), pp. 507-552.

EEA (2008), *Greenhouse Gas Emission Trends and Projections in Europe 2008: Tracking Progress Towards Kyoto Targets*, Copenhagen, Denmark.

Feng, Y., D. Fullerton and L. Gan (2005), "Vehicle Choices, Miles Driven and Pollution Policies", *Working Paper*, No. 11553, National Bureau of Economic Research, available at *www.nber.org/papers/w11553*.

Fullerton, D. and A. Wolverton (2005), "The Two-Part Instrument in a Second-Best World", *Journal of Public Economics*, Vol. 89, pp. 1961-1975.

Giuliano, G. and J. Dargay (2006), "Car Ownership, Travel and Land Use: A Comparison of the US and Great Britain", *Transportation Research Part A*, Vol. 40, pp. 106-124.

Golob, T.F. and D.A. Hensher (1998), "Greenhouse Gas Emissions and Australian Commuters' Attitudes and Behaviour Concerning Abatement Policies and Personal Involvement", *Transportation Research Part D*, Vol. 3(1), pp. 1-19.

Johansson-Stenman, O. (2002), "Estimating Individual Driving Distance by Car and Public Transport Use in Sweden", *Applied Economics*, Vol. 34(8), pp. 959-967.

Nolan, A. (2002), *The Determinants of Urban Households' Transport Decisions: A Microeconometric Study Using Irish Data*, No. 150, Royal Economic Society Annual Conference 2002, available at *http://repec.org/res2002/Nolan_A.pdf*.

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*, No. 3, pp. 147-162.

Steg, L., K. Geurs and M. Ras (2001), "The Effects of Motivational Factors on Car Use: A Multidisciplinary Approach", *Transportation Research Part A*, Vol. 35, pp. 789-806.

Stern, N. (2007), *The Economics of Climate Change: The Stern Review*, Cambridge, Cambridge University Press.

Train, K. (1980), "A Structured Logit Model of Auto Ownership and Mode Choice", *Review of Economic Studies*, Vol. 47(2), pp. 357-370.

WHO (2004b), *Health Aspects of Air Pollution – Results from the WHO Project "Systematic Review of Health Aspects of Air Pollution in Europe"*, WHO, Copenhagen.

WHO (2006), *WHO Air Quality Guidelines: Global Update 2005*, WHO.