Individual CO_2 emissions and the potential for reduction in the Netherlands and the United Kingdom

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Abstract

Using National Travel survey data from the Netherlands and the United Kingdom (UK), this paper examines how passenger transport emissions are divided across society and how similar this distribution is across these two countries. By looking across a series of data over time, the paper examines the extent to which the socio-economic characteristics of the main contributors of greenhouse gas (GHG) emissions are similar in these two countries. Based on the profiles of the main CO_2 contributor, relevant policy measures are examined. The general effectiveness and acceptability of these measures are then discussed by drawing on pan-European (Eurobarometer) survey results. Analyses reveal that around 10% of the Dutch population is responsible for almost half of all travel-related CO_2 emissions in the Netherlands. Similarly, in the UK, around 20% of the population is responsible of the 60% of passenger transport-related CO_2 emissions. Analysis of pan-European opinion surveys shows that there is a clear awareness among majority of the population that the type of car and the way it is used has an important impact on the environment. Despite this awareness, only a minority seem prepared to take action to reduce the environmnental consequences of their travel behaviour. The study supports the argument that the willingness to change behaviour is a complex mixture of individual and social interests. A major challenge is how to encourage changes in behaviour to reduce transport emissions with the right policies at the right time in the right place.

INTRODUCTION

Between 1990 and 2005, ,emissions of greenhouse gas (GHG) emissions from transport increased by almost 30%, of which 90% was produced by road transport (*1*). In the Netherlands, CO_2 emissions from land-based transport increased by 25% (*2*), representing an increase of more than 2% per year. This is in contrast to the GHG reduction targets agreed under the Kyoto Protocol, where the target of a 6% decrease in GHGs between 1990 and 2008-2012 was agreed for the Netherlands. Fortunately, other sectors in the Netherlands have not experienced such high increases in CO_2 emissions as in the transport sector, and total emissions of other GHGs have been reduced. The net effect is that emissions of all GHGs from the Netherlands (excluding those from air transport) have been stabilised between 1990 and 2005 (*3*). However, further increases in CO_2 emissions from the transport sector, now the largest and fastest growing source of CO_2 emissions in the Netherlands, may thwart the achievement of the Kyoto GHG emission target for the Netherlands as well as the European Union's recent GHG reduction target for 2020 (*4*). The UK also experienced similar trends. Transport is the only sector whose carbon emissions were higher in 2005 than they were in 1990..

Passenger transport currently accounts for more than half of the GHG emissions from the transport sector in both countries (*3,5*) and the great majority of passenger transport emissions originate from road-based transport. In 2005, more than 90% of all CO_2 emissions from land-based passenger transport originated from cars. Note that emissions from air travel are not included here – there is little data concerning the contribution of air transport to national CO_2 emissions (and emissions from air transport are excluded from the Kyoto targets). It is important to recognise however that air transport is an increasingly significant contributor of GHGs, mainly CO_2, since it is a rapidly growing sector and also has a greater effect on climate change as a consequence of being released at altitude (*6*).

Whilst car-based journeys dominate CO_2 emissions from land-based transport, only around half of all trips in the Netherlands are actually made by car (*7*). A further 45% of all trips are made by bicycle or foot and around 5% of trips are made by public transport. In other words, just under half of all trips contribute to 90% of all CO_2 emissions (i.e. those by car) and a similar proportion of trips (i.e. those by bicycle or foot) produce virtually no CO_2 emissions. In the UK, the proportion of car journeys is higher but still not proportional with its share of emissions. One of the most noticeable differences between the modal split in the two countries is the proportion of journeys by bicycle. In the Netherlands, more than a quarter of all journeys are by bicycle whereas only 1% of journeys are by bicycle in the UK (*2, 5*).

The aim of this paper is to explore the influence of individual socio-demographic characteristics to the transport emissions. We examine who produces the most emissions, who produces the least, how these emissions are divided across society and how similar this distribution is across the two European countries. This paper focuses on passenger transport and looks at daily travel distance, energy consumption and CO_2 emissions of individuals in the UK and the Netherlands. It uses national travel data for both countries from a number of different years since 1990s to examine individual travel distance, energy consumption and CO_2 emissions over time. It then constructs a classification of individuals based on their travel patterns and CO_2 emission profiles with the aim of identifying the key socio-economic characteristics of individuals with high and low CO_2 emission profiles. By looking across a series of data over time, the paper examines the extent to which the socio-economic characteristics of the main contributors of GHG emissions are the similar in both countries. Then, based on pan-European (Eurobarometer) survey results (*8*), the effectiveness and the acceptability of various policy measures in reducing individual transport CO_2 emissions among various socio-demographic groups of individual are explored. Policy acceptability and the challenges to reducing CO_2 emissions according to different socio-economic groups are discussed.

The main objective of the study is to examine the distribution of CO_2 emissions between different socio-economic groups in the UK and the Netherlands, rather than comparing the exact amount of individual CO_2 emissions in these two countries. The latter is not feasible due to the different definitions and data collection methods in the two countries.

The next section presents the dataset and the methodology. Then, an explanatory analysis of the data between 1990 and 2005 is presented according to a number of socio-economic variables including gender, employment status, personal income, age, household size and household composition. It is of course recognised that there are a range of interrelationships between these variables. It is also recognised that there is also substantial day-to-day variability in travel behaviour (*9*), although this is unlikely to affect the main messages emerging from the analysis of the distribution of CO_2 emissions. Differences in attitudes regarding policies for reducing transport energy across different socio-economic groups are examined.

DATA AND METHODOLOGY

This paper draws on data from the UK and the Dutch National Travel Survey (NTS) which provides detailed information about individuals, households and their trips for the last three decades. The UK National Travel Survey (NTS) is a series of household surveys designed to provide regular, up-to-date data on personal travel and monitor changes in travel behaviour over time. The first UK NTS was commissioned by the Ministry of Transport in 1965/66. Further periodic surveys were carried out in 1972/73, 1975/76, 1978/79 and 1985/86 (data is available from 1972 onwards). Since July 1988 the NTS has been carried out as a continuous survey with field work being carried out in every month of the year and an annual set sample of over 5000 addresses (*10*). Because of accuracy and comparability issues, this paper only uses the UK data from 2000 and 2004 datasets.

The Dutch NTS data have been collected continuously by Statistics Netherlands since 1978 using travel diaries. For each year up to 1993, the NTS recorded data for approximately 10,000 households, 20,000 individuals (and more than 80,000 trips). During 1994 and 1995 the NTS was extended to include substantially more respondents and households each year and also to include children younger than 12, who were previously excluded from the survey (*11*). Because of some differences in the way of recording certain variables before 1990, this paper only uses NTS data from 1990 onwards.

Emissions of CO_2 per person were calculated for four different years between 1990 and 2005 at 5-year intervals for the Netherlands (1990, 1995, 2000 and 2005) and for two different years for the UK (2000 and 2004) using information from NTS data about each trip (mode, distance, fuel type, vehicle age, occupancy and speed) together with vehicle emission factors from COPERT, a computer programme to calculate emissions from road transport developed for the European Environment Agency (*12*). In this approach, the CO_2 emissions were calculated base on the distance travelled by the travellers and the journey characteristics, such as travel speed and vehicle occupancy. Each vehicle type has its own equation based on its age, fuel type and operating speed. For example, the amount of CO_2 emission of gasoline light duty vehicle (<3.5t) produced after 1996 is ($0.0621V^2 - 9.8381V + 601.2$) grams of CO_2/km (where V=operating speed). Seventeen different equations (based on vehicle age and type) were used in this study. For journeys by public transport modes, information about mode and distance only were used to calculate CO_2 emissions using typical emission factors for the Netherlands according to analysis by van den Brink & van Wee (*13*) and for the UK according to figures from Transport Direct (*14*) – a UK online travel planning service jointly funded by the UK Department for Transport, the Welsh Assembly and the Scottish Government. Journeys by foot and cycle were assumed to entail no CO_2 emissions. Emissions from air travel were omitted from the analysis (see above).

TRENDS AND ANALYSES

Recent trends in the Netherlands

In many ways, general travel patterns in the Netherlands did not change substantially between 1990 and 2005. According to Dutch NTS data, average travel distance per person per day, travel speed and time spent travelling all remained fairly constant during the 15-year period between 1990 and 2005. What did change, however, is the average number of trips, which decreased by 14% during this period, and travel-related CO_2 emissions, which increased on average by 16% between 1990 and 2005. The decrease in the average number of trips may be mainly due to various changes between 1990 and 2005 in data collection methods and definitions of journeys (*11*). Very short trips, such as short distance walks, which were recorded in the earlier version of the survey, were removed in later surveys. Some frequent trips that are part of work activities (e.g. delivery workers' or taxi drivers' trips) were recorded as one trip. However, since the total travel distance and time were still recorded, this adjustment would not significantly influence the emissions and energy calculation in this study (*7*).

The increase in CO_2 emissions per capita can be mainly attributed to decreases in travel distance by less energy intensive modes (e.g. bicycle and public transport) and increases in travel distance by certain more energy intensive modes (e.g. motorcycle) and for certain frequent trips, such as commuting trips. Average trip distance by bus/tram/metro and bicycle decreased by 30% and 15% respectively between 1990 and 2005, whilst average trip distance by motorcycle increased by more than 50% over the same period. Estimates of annual CO_2 emissions using the average daily emissions calculated for 1990, 1995 and 2000 correspond well with official data for annual emissions, despite the fact that NTS data only record travel information for one day.

Recent trends in the United Kingdom

In the UK, the number of trips per person fell slightly between 1995 and 2005, whilst the average distance travelled increased slightly. This reflects an increase of 7 percent in average trip length over the same period. Interestingly, the average trip time increased between 1995 and 2005 by 9 percent to 22 minutes. As a result, the average time spent travelling increased from 369 hours per person per year (about an hour a day) to 385. The number of trips by bicycle and on foot declined by over 15 percent between 1995 and 2005 (*15*). Unlike the Netherlands, the proportion of non-motorised travellers in the UK is relatively low, it is about 15% in 2000 and 2004. As a result, the average British traveller is responsible for 17% more transport emissions than his/her Dutch counterpart, with fewer trips, longer travel times and similar travel distances.

Gender

Between 1990 and 2005, there has been a consistent and substantial difference in transport-related CO_2 emissions between men and women in both countries (Figure 1). Men account for around two-thirds of these CO_2 emissions whilst women account for approximately one-third. The growth in CO_2 emissions has however been higher for women than men during this 15-year period, suggesting a slight trend towards convergence. Travel distances covered by men are also consistently and substantially higher than those of women. As in the case of CO_2 emissions, men account for around two-thirds of all travel distance whilst women account for approximately one-third. On average, men also spend 10-20% more time travelling than women. In terms of the number of trips, however, it is women who consistently make slightly more trips than men.

Employment

People in full-time employment account for more than 50% more transport-related CO_2 emissions than those in part-time employment and more than double the CO_2 emissions of people who are not in employment (Figure not shown in here). In the Netherlands, between 1990 and 2005, the highest rate of growth in CO_2 emissions has taken place amongst people in full-time employment. CO_2 emissions from people who are not in work, on the other hand, did not increase during this period. Similarly, people in full-time work consistently travel furthest and spend most time travelling whilst people who are not in work cover the shortest distance and spend the least amount of time travelling. Interestingly, people who work part-time consistently make more trips. There was not any significant different among UK respondent from 2000 to 2004, though the graphs tend to show some decline trends in all parameters. In all parameters, UK respondents tend to produce more emissions and travel further with fewer trips.

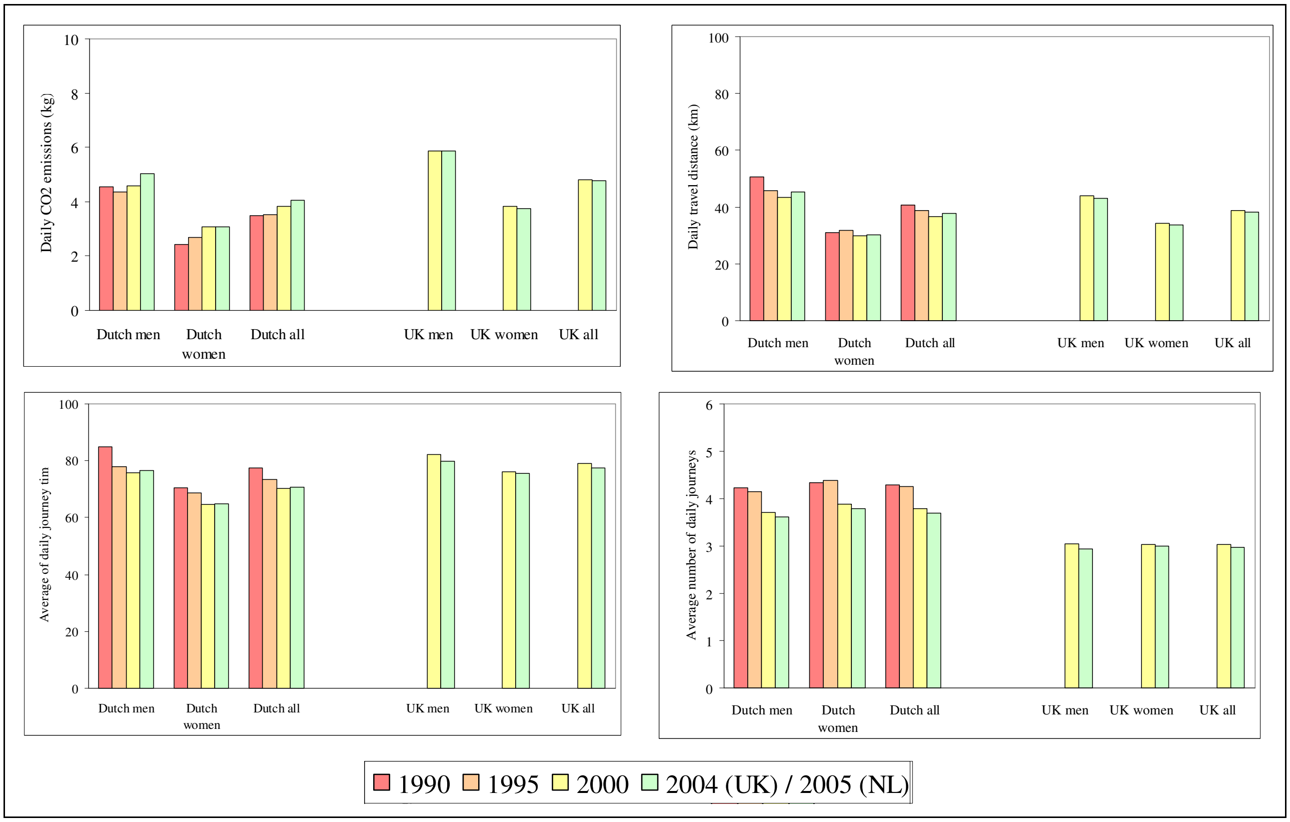


FIGURE 1 Travel trends in the Netherlands and in the UK according to gender

Income

Transport-related CO_2 emissions are consistently and substantially higher for people with higher personal incomes (Figure 2). In the Netherlands, the rate of growth of CO_2 emissions between 1990 and 2005 for people with higher incomes has been much faster than for people in other income categories. People in the low-income category account for less than one third of the CO_2 emissions compared to people in the high-income category. Similar observations can be made for travel distance and travel time: people with high incomes travel longer distances and spend more time travelling whilst people with low incomes travel shorter distances and spend less time travelling. Although people with higher incomes also make slightly more trips than others, the difference in the number of trips between different income groups is fairly low.

Household composition

In the Netherlands, residents of households containing children (under the age of 18) account for lower levels of transport-related CO_2 emissions; residents of households containing no children and more than one adult account for higher levels of transport-related CO_2 emissions (Figure not shown in here), but the difference is not so clear in UK households. In the Netherlands, the fastest growth of CO_2 emissions between 1995 and 2005 was for residents of households having dependent children; CO_2 emissions for residents of other types of households did not change very much during this period. This indicates a possible trend towards convergence in CO_2 emissions between different household types. In terms of travel distance, residents of households with more than one adult and no children consistently travel furthest. The relationship between household composition and time spent travelling is unclear. What is clear however is that, in the Netherlands, between 1995 and 2005, residents of households with children consistently spent the least amount of time travelling than the residents of other household types. In terms of the number of trips, residents of households containing children make the most number of trips whilst residents of households containing no children make fewer trips than average.

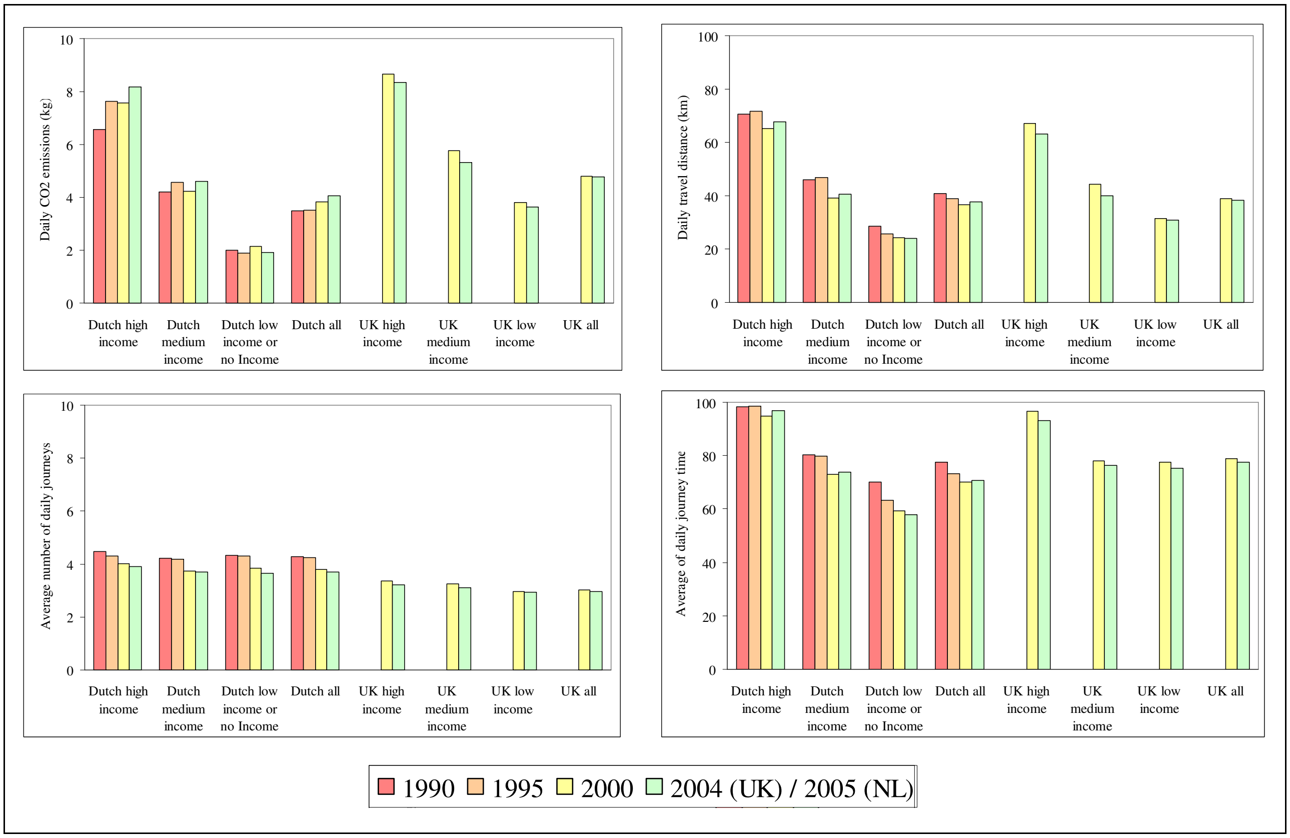


FIGURE 2 Travel trends in the Netherlands and in the UK according to personal income.
Note: The higher personal income category in the Netherlands was defined as €30,000 (net) or more per year for 1990 and 1995, and €35,000 (net) or more per year for 2000 and 2005; whilst the higher personal income category in the UK was defined as more than £ 20,000 (gross) per year. And for the lower income category, in the Netherlands was defined as less than €15,000 (net) per year whilst the lower personal income category in the UK was defined as less than £ 10,000 (gross) per year.

WHO PRODUCED MOST POLLUTION IN THE LAST DECADE?

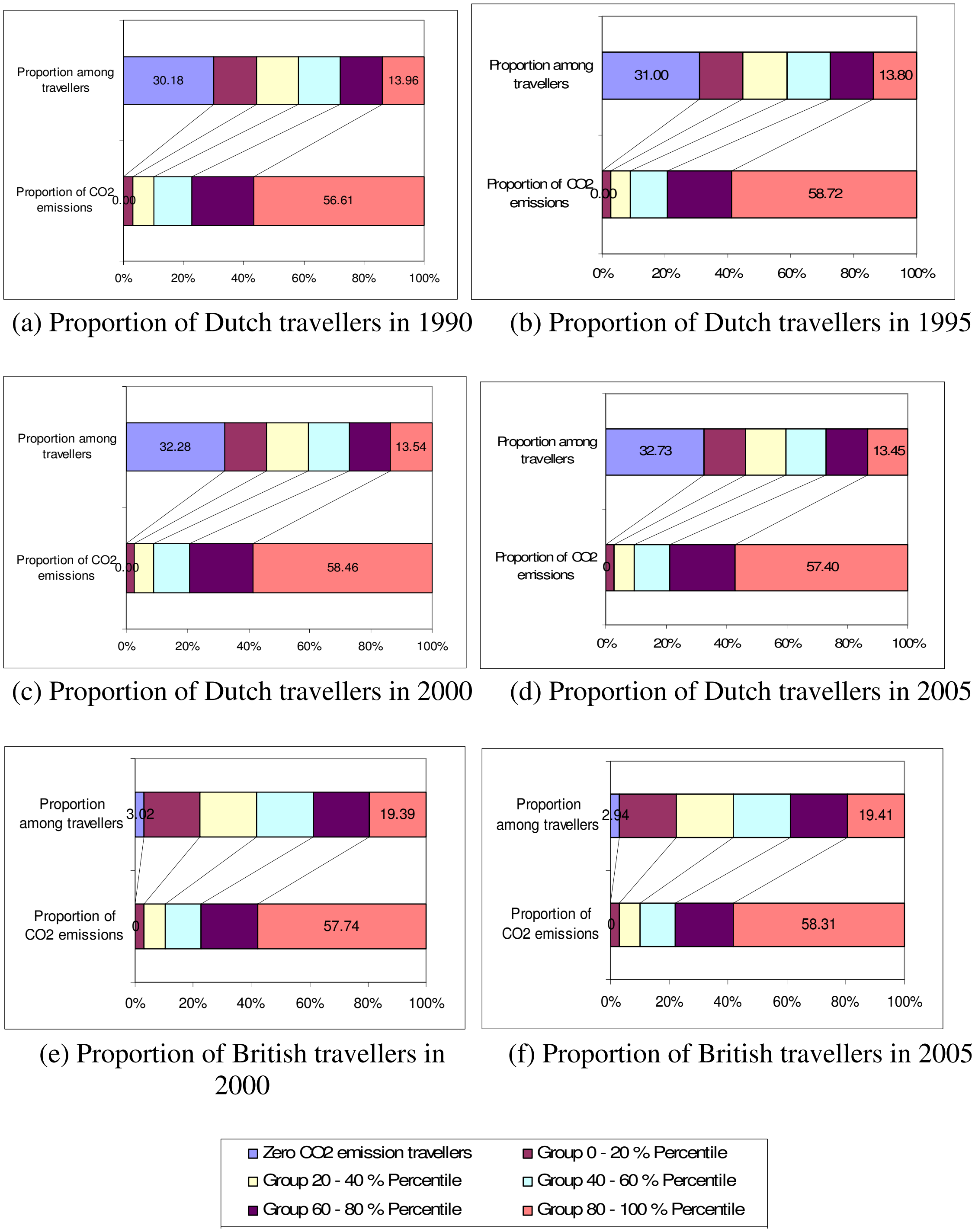
In order to explore individual CO_2 emissions according to different socio-demographic groups, the study differentiates between five different groups (quintiles) based on their transport emissions. A sixth group containing zero emission travellers (100% non-motorised travellers during the observed days) is also identified.

Looking across the six categories of respondents classified according to their CO_2 emissions (Figure 3), three key trends over time are apparent. Firstly, the proportion of individuals in the zero-emissions category stayed fairly stable over time and, rather surprisingly, increased slightly between 1990 and 2005: in the Netherlands, 30% of survey respondents were found in this category in 1990; in 2005 the proportion of respondents in this category was close to 33%. In other words, around one third of the survey respondents generated no travel-related CO_2 emissions on the day that they were surveyed. In the UK, this zero emissions travellers are only about 3% of survey respondents. This might also due to UK NTS observed a longer period than Dutch NTS, which increases the chances of travellers to change their mode from non-motorised to motorised modes. Nevertheless, if we explore further day-by-day emissions from the UK data set, less than 10% of day-trip in the UK has zero CO_2 emissions.

Secondly, the proportion of car trips for all categories of respondents stayed quite stable between the observed periods (not shown). In the Netherlands, about 13% of respondents are responsible for almost 60% of transport emissions, whilst in the UK this proportion of emissions were produced by 20% of the respondents. On average, British respondents produced 800-1,000 grammes (18-26%) more CO_2 emissions per day than Dutch respondents during the observed period.

Thirdly, looking across all examined periods, the top quintile of respondents (classified according to their CO_2 emissions) make between 10% and 20% more journeys than average, undertake significantly more journeys by car than average (and fewer by foot, bicycle or public transport), spend about twice the average amount of time travelling (at twice the speed), cover more than three times the average distance and produce around 3-4 times the average amount of CO_2 emissions. The lowest quintile of respondents, on the other hand, make fewer journeys than average (by around 10-15%), make significantly more journeys by public transport than average, spend substantially less time travelling (at a lower than average speed), cover less than a quarter of the average distance and produce around a fifth of the average amount of CO_2 emissions.

Comparing the socio-demographic characteristics among different groups of respondents, the main polluters were the same types of people as might be expected: men rather than women; higher income groups; members of smaller households; and people with access to private vehicle (85% of their trips were using a private vehicle). Interestingly, while zero CO_2 emissions travellers in the Netherlands were dominated by women, this is not the case with British respondents. This is undoubtedly a consequence of much higher levels of accessibility by foot/bicycle in the Netherlands compared to the UK.



(a) Proportion of Dutch travellers in 1990

(b) Proportion of Dutch travellers in 1995

(c) Proportion of Dutch travellers in 2000

(d) Proportion of Dutch travellers in 2005

(e) Proportion of British travellers in 2000

(f) Proportion of British travellers in 2005

FIGURE 3 Proportion of travellers against their transport CO_2 emissions.

TABLE 1 The Characteristics of Zero-emissions Travellers and the Highest Quintile of CO_2 Emissions

Zero CO_2 emissions travellers		Highest quintile of travellers	
UK NTS	Dutch NTS	UK NTS	Dutch NTS
Slightly more men than women, relative high proportion of younger people, unemployed, larger household size and people below average income Very low proportion of people aged between 25 and 64, and people with above average incomes. Very few (11%) of them who had an access to a car	Relatively high proportion of women, younger people (aged 24 or under), older people (aged 65 or older), students, non-workers, people with below average incomes Relatively low proportion of people aged between 25 and 64, people with higher education, and people with above average incomes. 40% of them had access to a car	More men than women Fewer younger respondents More respondents aged between 25 and 64 Fewer older respondents More full-time workers Fewer students Smaller household size More respondents with access to a car More than 85% of all trips by car	More men than women Fewer younger respondents More respondents aged between 25 and 64 (people on productive age) Fewer older respondents More full-time workers Fewer students More respondents with higher education Fewer respondents with dependent children More respondents with access to a car More than 85% of all trips by car

ARE THE RELATIONSHIPS CONSTANT OVER TIME?

In order to test the whether relationships between individual CO_2 emissions and socio-economic variables constant over time, a regression analysis is employed (Table 2 and 3 for Dutch and British case, respectively). Whilst the R^2 values for the analyses are all relatively low, the results show reasonable consistency across the four years examined (for more complete discussion on estimation results, see Susilo & Stead (16)).

As shown in Table 2, in the Netherlands, the influence of being a full-time worker and accessibility to private car has increased over time between 1990 and 2005. Car accessibility increased daily CO_2 emissions by 2.2, 2.3, 2.5, and 2.7 kilogrammes in 1990, 1995, 2000 and 2005 respectively whilst being in full-time work increased CO_2 emissions by 1.3, 1.3, 2.2, and 2.4 kilogrammes more than non-workers in 1990, 1995, 2000, and 2005 respectively. Men consistently account for more CO_2 emissions than women.

Echoing trends among Dutch respondents, in the UK, men, full-time workers and respondent with car access produced more emissions than others. Men produced 1.1 and 1.2 kilogram CO_2 emissions more than women in 2000 and 2004, respectively. Interestingly, high income dummy and household size variables are not significant for UK respondents. Medium income respondents produce more CO_2 emissions than high and low income respondents (see Table 3). The results of the regression analyses do not change substantially if land-use variables are also introduced (the detailed results are not shown here).

TABLE 2 Regression Analysis of Individual CO_2 Emissions with Socio-economic Variables, in the Netherlands, 1990-2005

	1990		1995		2000		2005	
	Coeff.	t-stats	Coeff.	t-stats	Coeff.	t-stats	Coeff.	t-stats
Constant	481.63	1.95	1113.96	8.34	792.32	2.32	104.32	0.68
Male	974.57	8.76	683.62	14.29	554.57	3.50	730.14	10.85
Age < 25	57.87	0.21	453.33	3.78	848.21	2.28	1333.41	8.17
Age 25-44	119.24	0.54	127.64	1.12	394.14	1.22	886.80	6.50
Age 45-64	287.99	1.39	200.50	1.92	400.43	1.41	449.63	3.87
Full-time worker	1278.97	8.39	1333.34	17.33	2244.62	9.20	2378.51	22.31
Part-time worker	423.95	2.40	422.96	4.97	1753.76	6.28	645.23	5.33
Student	667.36	2.82	98.17	1.16	328.47	1.17	37.28	0.31
2 person household	-166.94	-0.88	-113.23	-1.18	-120.43	-0.47	-123.64	-1.18
3 person household	-285.14	-1.36	-281.95	-2.61	-689.71	-2.23	-1.28	-0.01
4 person household	-426.68	-2.14	-541.73	-5.07	-621.69	-2.03	-342.52	-2.67
5 person household	-646.77	-2.86	-508.10	-4.31	-825.00	-2.32	-388.42	-2.59
6+ person household	-1059.57	-3.36	-542.48	-3.81	-784.13	-1.68	-176.81	-0.86
Households with children	N/A	N/A	-323.01	-4.92	-49.62	-0.23	-281.85	-3.12
Higher education	629.14	3.64	735.04	8.17	691.55	2.47	728.35	6.05
Tertiary education	265.54	2.20	47.08	0.67	198.79	0.93	45.01	0.48
High income	1899.14	8.22	2376.74	21.95	1583.04	4.63	2112.50	13.93
Medium income	378.41	2.74	247.47	3.41	-297.24	-1.39	208.98	1.95
Car availability	2206.00	17.97	2341.11	35.16	2449.89	11.67	2721.79	29.43
N	13040		97877		112741		50155	
Mean	3479.29		3526.10		3816.84		4044.04	
SD	5566.92		6873.69		23595.19		7106.74	
R^2	0.113		0.101		0.009		0.129	
Adjusted R^2	0.112		0.101		0.009		0.129	

POLICY ACCEPTABILITY AND EFFECTIVENESS AMONG DIFFERENT GROUP OF INDIVIDUALS

As shown in the previous section, certain types of individuals tend to produce more CO_2 emissions than others. In this section, attitudes of various types of individuals toward various transport policy is explored based on the results of the recent 2007 Special Eurobarometer Survey on transport policy (*8*). Special Eurobarometer surveys concern a range of subjects (recent topics have included attitudes to climate change, radioactive waste, the European common agricultural policy, and European development aid) and are carried out from time to time as part of the polling waves for the standard Eurobarometer survey. The latter survey is a regular monitoring exercise employing similar questions in each survey concerning social and political attitudes in the European Union.

TABLE 3. Regression Analysis of Individual CO_2 Emissions with Socio-economic Variables, in the UK, 2000&2004

	2000		2004	
	Coeff.	t-stats	Coeff.	t-stats
Constant	2072.92	6.18	1668.46	7.95
Male	1113.68	5.52	1269.61	10.36
Age < 25	-656.84	-1.65	387.43	1.59
Age 25-44	-117.79	-0.29	587.75	2.39
Age 45-64	634.43	1.84	768.43	3.60
Full-time worker	1919.84	5.41	1480.87	7.02
Part-time worker	656.49	1.92	226.53	1.06
Student	387.96	0.60	-318.35	-0.86
2 person household	850.10	2.60	138.98	0.69
3 person household	123.20	0.30	172.03	0.68
4 person household	464.28	1.05	221.15	0.82
5 person household	571.39	1.09	111.37	0.36
6+ person household	665.33	1.05	119.46	0.33
Households with children	534.73	1.61	50.10	0.26
High income	375.22	1.15	157.15	0.85
Medium income	2648.65	7.02	2403.56	11.20
Car availability	518.80	2.00	1470.25	9.37
N	7420		18447	
Mean	4802.54		4763.58	
SD	8331.75		8119.97	
R^2	0.067		0.077	
Adjusted R^2	0.065		0.076	

The recent 2007 Special Eurobarometer Survey on transport policy (*8*) provides a number of insights into public attitudes regarding policies for reducing transport-related energy and CO_2 emissions across different socio-economic groups (and also between different countries in Europe). It highlights for example some clear differences in attitudes across different socio-economic groups concerning the types of measures that could improve traffic problems in urban areas, the types of measures that could be used to address transport-related CO_2 emissions, the preparedness to pay for providing less polluting modes of transport or purchasing less polluting fuels, and the preparedness to pay for congestion. The survey covered all 27 Member States of the European Union on a randomly selected sample of over 25,767 individuals over 15 years of age (approximately 1,000 respondents in each Member State, except for Malta, Cyprus and Luxembourg where there were only approximately 500 respondents).

The Eurobarometer survey shows a number of similar differences in attitudes concerning *measures to reduce CO_2 emissions from road transport* according to gender, age and level of education. A higher proportion of women than men favour measures to restrict the use of cars and increase information to promote the purchase of more fuel efficient vehicles (Table 4). On the other hand, a higher proportion of men than women favour tax incentives to promote the purchase of fuel efficient vehicles. Older respondents are more likely to favour measures to restrict the use of cars than younger respondents. Conversely, measures such as increasing information to promote the purchase of more fuel efficient vehicles are less favoured by older respondents. More educated respondents are more likely to favour measures such as tax incentives to promote the purchase of fuel efficient vehicles, and are less likely to favour measures such as restricting the use of cars. Overall, measures such as restrictions on vehicle sales and tax incentives to promote the sale of more efficient vehicles are favoured most, whilst measures restricting the use of cars are least popular.

TABLE 4 Support for Measures to Reverse the Rise of CO_2 Emissions

	Introduce restrictions to the use of cars (%)	Only allow the sale of less polluting vehicles (%)	Promote the purchase of fuel efficient vehicles by giving better information (%)	Promote the purchase of fuel efficient vehicles through tax incentives (%)	DK/NA
Sex:					
Male	9.8	33.2	15.5	33.2	8.2
Female	11.6	36.7	17.1	26.8	7.8
Age:					
15-24	11.5	34.7	21.0	28.6	4.2
25-39	8.7	33.9	17.0	35.3	5.1
40-54	10.1	34.3	15.2	32.9	7.5
55+	12.6	36.7	14.6	23.7	12.4
Age of completing education:					
15	14.1	38.1	14.2	20.9	12.6
16-20	9.8	34.4	17.0	31.0	7.9
20+	9.9	33.9	15.8	34.7	5.7
EU27	**10.8**	**35.0**	**16.3**	**29.9**	**8.0**

Source: European Commission (*8*)

In terms of the types of *measures to improve traffic problems* in urban areas, there are some noticeable differences in attitudes by gender, age and level of education. A higher proportion of men than women favour measures such as public transport improvements, vehicle access and parking restrictions and charges for road use (Table 5). On the other hand, a higher proportion of women than men favour measures such as speed limits. Older respondents are more likely to favour measures such as public transport improvements and speed limits more than younger respondents. Conversely, measures such as vehicle access and parking restrictions and charges for road use are less favoured by older respondents. More educated respondents are more likely to favour measures such as public transport improvements and speed limits, and are less likely to favour measures such as vehicle access and parking restrictions and charges for road use. Overall, measures such as public transport improvements are favoured most, whilst measures such as road charging are least popular.

TABLE 5 Support for Measures to Improve Traffic Problems in Urban Areas

	Better public transport (%)	Restrict-ions in city centres (parking, access for cars or trucks) (%)	Speed limits (%)	Charges for road use (e.g. city tolls) (%)	No need for improve-ment (%)	Other (%)	DK/NA (%)
Sex:							
Male	49.1	17.9	12.5	5.8	6.3	5.4	3.1
Female	48.0	15.9	20.3	3.9	5.5	2.3	4.2
Age:							
15-24	47.6	20.2	17.1	6.8	4.3	2.1	1.9
25-39	50.7	18.6	15.5	5.0	4.3	3.0	2.8
40-54	53.1	15.1	13.3	5.0	6.4	4.4	2.8
55+	43.1	15.4	19.9	3.6	7.4	4.7	5.9
Age of completing education:							
15	44.3	12.1	21.2	2.5	7.6	4.9	7.4
16-20	47.7	17.4	17.2	4.7	6.2	3.4	3.5
20+	52.6	18.2	12.5	5.7	5	4.1	1.9
EU27	**48.5**	**16.8**	**16.5**	**4.8**	**5.9**	**3.8**	**3.7**

Source: European Commission (*8*)

TABLE 6 Preparedness to Pay More to Use Less Polluting Transport

	Not prepared to pay more (%)	Prepared to pay up to 10% more (%)	Prepared to pay more than 10% (%)	DK/NA
Sex:				
Male	43.2	42.3	10.8	3.7
Female	38.9	47.9	7.7	5.5
Age:				
15-24	34.4	49.7	12.1	3.8
25-39	40.5	45.7	10.3	3.4
40-54	41.2	46.9	8.3	3.7
55+	43.8	41.6	7.8	6.8
Age of completing education:				
15	46.5	40.7	4.9	7.9
16-20	44.3	44.5	7.1	4.0
20+	35.5	47.2	14.0	3.2
EU27	**41.0**	**45.2**	**9.2**	**4.6**

Source: European Commission (*8*)

The Eurobarometer survey reveals some differences in the *preparedness to pay for using less polluting transport* according to socio-economic variables such as gender, age and level of education. Overall, more than half of all respondents (54%) are prepared to pay more for travel in order to use less polluting transport. Men are less prepared than women to pay more to use less polluting transport (Table 6) and more women than men are prepared to pay above 10% more for travel in order to use less polluting transport. However, somewhat at odds with this is the statistic that more men than women are prepared to pay up to 10% more for travel in order to use less polluting transport. Older respondents are the least prepared to pay more to use less polluting transport. Younger and more educated respondents are the most prepared to pay more for travel in order to use less polluting transport.

Preparedness to pay for congestion through road tolls is also examined in the 2007 Eurobarometer Survey. Just over a third of all respondents agree that road users should pay for congestion through road tolls (Table 7). There is little difference between men and women in support for road tolls to pay for congestion and environmental damage. Younger and more educated respondents are more likely to favour road tolls; older respondents and those who have received less education are least likely to favour such tolls. These findings are in line with the results in the UK by Lyons *et al.* (*17*) which are based at the British Social Attitudes Survey (BSAS). They show that a large proportion of respondents reject the proposition '*People should be allowed to use their cars as much as they like, even if it causes damage to the environment*' – just under 40% compared with just under 25% agreeing. A survey of public attitudes and behaviour towards the environment for DEFRA (*18*) in the UK revealed that only 25% of respondents agreed with the proposition '*For the sake of the environment, car users should pay higher taxes*'. The percentages were highly influenced by the rate of car ownership and there was only little difference as between cities, towns and rural areas.

TABLE 7 Opinions about Whether Road Users should Pay for Congestion and Environmental Damage through Road Tolls

	Agree (%)	Disagree (%)	DK/NA
Sex:			
Male	34.9	60.8	4.3
Female	34.5	58.9	6.6
Age:			
15-24	41.2	55.9	2.9
25-39	34.7	61.7	3.6
40-54	32.3	63.0	4.7
55+	33.9	57.3	8.7
Age of completing education:			
15	32.7	58.0	9.3
16-20	32.0	62.7	5.3
20+	36.1	60.3	3.6
EU27	**34.7**	**59.8**	**5.5**

Source: European Commission (*8*)

The Eurobarometer survey shows that even within the same group of people, there is a significant different of attitudes towards the policy measurements. This is understandable because the acceptance to a certain policy not only depends on individual characteristics, but also their attitudes. Lyons *et al.* (*17*) noted that different groups or segments of the population would have a substantially different readiness to change their choices, which depends on their current travel patterns and their outlook and circumstances. A recent research report on public attitudes to road pricing (*19*) notes,"[a]lthough respondents were aware of the effects of congestion on the environment, they did not raise this as a key concern. Some respondents believed buses to be the main pollutants on the roads and thought that measures to cut pollution should focus on buses rather than cars". A recent UK study on driving behaviour (eco-driving) found that 34% of respondent agreed with the statement '*It would be difficult to change my driving behaviour, even if it would help the environment*' (*20*). Another recent UK study suggests that people may be more prone to change behaviour if the benefit is a proximate one to the individual, his/her family, or the local community, such as improving children's fitness, improving local air quality or saving money (*21*). It is important to recognize here that stated preferences and responses to policies can be quite different to actual preferences and responses. Rienstra et al (*22*) for example speculate that 'painful policy measures' may be rated as less effective in an attempt to try to justify the rejection of these measures and/or try to reduce the likelihood of their implementation.

In order to explore this issue further, attitudinal analysis of how social groups respond to different policy options in both the UK and the Netherlands is needed. This will be the focus in future research building on this study.

CONCLUSIONS

In the United Kingdom and in the Netherlands, as in most countries, transport energy use and CO_2 emissions continue to grow and may thwart the achievement of the national GHG emission target agreed at Kyoto as well as the European Union's recent GHG reduction target for 2020. The transport sector in both countries is currently responsible for about a fifth to a quarter of all national CO_2 emissions, and passenger transport currently accounts for more than half of the GHG emissions from this sector. Whilst car-based trips dominate CO_2 emissions from passenger transport, only around half of all trips in the Netherlands and 60% of all trips in the UK are made by car. Thus, certain trips produce a disproportionately high amount of CO_2 emissions whilst other trips produce zero emissions.

Using the UK and the Dutch National Travel Survey, this paper has identified trends in transport-related CO_2 emissions over time and examined the relationships between individual CO_2 emissions and socio-economic variables. The analysis results reveal that the proportion of individuals with zero-emissions from transport in the Netherlands has consistently stayed around the 30% mark and actually increased slightly between 1990 and 2005. Respondents in the highest quintile produce than four times the average amount of CO_2 emissions whilst those in the lowest quintile produce less than a quarter of the average amount of CO_2 emissions. The difference in average CO_2

emissions between the highest and lowest quintile is typically around 20-fold. There is thus a relatively large proportion of people producing very low quantities of CO_2 emissions, and a small proportion of people producing the majority of the emissions: half the population is responsible for about 10% of travel-related CO_2 emissions whilst another 10% of the population is responsible for almost half of all travel-related CO_2 emissions. While in the UK, 60 % of the population is responsible of 20 % of the emissions whilst another 20% of the population is responsible of the 60% of the CO_2 emissions.

The socio-economic characteristics of the six different categories of respondents grouped according to their travel-related CO_2 emissions are in line with results of other studies into the socio-demographics of transport emissions (*23-26*). One of the implications of these findings is that the reduction of CO_2 emissions in the upper quintile by a given proportion (e.g. 10%) will lead to a larger reduction of CO_2 emissions than a reduction of CO_2 emissions by the same proportion for all other four quintiles. Achieving reductions in the upper quintile is not likely to be easy however. Recent European public opinion surveys on transport policy reveal that attitudes regarding policies for reducing transport-related energy and CO_2 emissions vary considerably across different socio-economic groups. In some cases, the groups responsible for high CO_2 emissions are the most supportive of measures to reduce these emissions. In many other cases however the opposite is true: the groups responsible for high CO_2 emissions are the least supportive of measures to reduce these emissions.

While there is a clear awareness among the majority of the population that travel has an important impact on the environment, the willingness to change behaviour is a complex mixture of individual and social interests. Different groups or segments of the population have different needs and their readiness to change their travel behaviour can differ substantially. This raises an important (but at present unresolved) question of interpretation (*17*). At one extreme, it might be that the different segments of the population represent different stages in a dynamic process where individuals switch from one group to another as their lives and experiences change. At the other extreme, it might be that these different segments are more fixed and related to individual characteristics which are resistant to change. The policy and behavioural implications of both options are considerable and merit further investigation.

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REFERENCES

1. European Environment Agency. Annual European Community greenhouse gas inventory 1990–2005 and inventory report 2007. *Technical report No 7/2007*. European Environment Agency, Copenhagen, 2007.

2. Statistics Netherlands. *StatLine – online database of Statistics Netherlands* (www.statline.nl), accessed on October 2007.
3. Netherlands Environmental Assessment Agency. Greenhouse gas emissions in the Netherlands 1990-2004. *National Inventory Report 2006*. MNP report 500080001/2006. Netherlands Environmental Assessment Agency (MNP), Bilthoven, 2006.
4. European Commission. Commission proposes an integrated energy and climate change package to cut emissions for the 21st Century. *European Commission Press Release IP/07/29* (10/01/2007). European Commission, Brussels, 2007.
5. Commission for Integrated Transport. *Transport and Climate Change*. CfIT, London, 2007.
6. Penner, J.E., D. Lister, D.J. Griggs, D.J. Dokken, and M. McFarland. Aviation and the Global Atmosphere. *IPCC Special Report*. Cambridge University Press, Cambridge, 1999.
7. Susilo, Y. and D. Stead. Urban form, vehicle emissions and energy use of commuters in the Netherlands. *Proceedings of the eceee Summer Study, 4-9 June 2007*. European Council for an Energy Efficient Economy (eceee), Stockholm, 2007.
8. European Commission. Attitudes on issues related to EU Transport Policy. Analytical report. *Flash Eurobarometer 206b*. European Commission, Brussels, 2007.
9. Susilo, Y.O. & Kitamura, R. Analysis of Day-to-Day Variability in an Individual's Action Space: Exploration of 6-Week Mobidrive Travel Diary Data. Journal Transportation Research Record, Vol, 1902, 2005, pp. 124-133.
10. ESDS. *Economic and Social Data Service website: National Travel Survey* (http://www.esds.ac.uk/government/nts), accessed on October 2007.
11. van Evert, H., W. Brog, and E. Erl. Survey Design: The Past, the Present and the Future. In: Stopher, P. and C. Stecher (eds.). *Travel Survey Methods – Quality and Future Directions*. Elsevier, London, 2006.
12. Ntziachristos, L and Z. Samaras. COPERT III – Computer programme to calculate emissions from road transport. Methodology and emission factors. *EEA Technical Report No 49*. European Environment Agency, Copenhagen, 2000.
13. van den Brink, R. and G.P. van Wee. Energiegebruik en emissies per vervoerwijze. [Energy use and emissions by transport mode]. *RIVM Report 773002007*. National Institute for Public Health and the Environment (RIVM), Bilthoven, 1997.
14. Transport Direct. Carbon Emission Assumptions. *Transport Direct document* (http://www.transportdirect.info/Downloads/TransportDirectCO2Data.pdf), accessed on November 2007.
15. Department for Transport. *Transport Statistics for Great Britain: 2006 Edition*. TSO, London, 2006.
16. Susilo, Y. and D. Stead. Individual CO_2 Profiles from passenger transport in the Netherlands and the United Kingdom. *The 40th UTSG Annual Meeting*, Southampton, UK, 2008.
17. Lyons, G., P. Goodwin, M. Hanly, G. Dudley, K. Chatterjee, J. Anable, P. Wiltshire, and Y. Susilo. *Public attitudes to transport: Knowledge review of existing evidence*, Final Report for Department for Transport, United Kingdom, 2008.
18. DEFRA. *Survey of public attitudes and behaviours toward the environment: 2007*. Department for Environment Food and Rural Affairs, London, 2007.

19. Green, E. and V. Stone. *Public attitudes to road pricing in the UK: a qualitative study* - Report to the Department for Transport, 2004.
20. Angle H., T. Brunwin, R. Gosling, and K. Buckley, *Climate change behaviour stage: Driving behaviour and car purchasing*. Report for the Department for Transport by the British Market Research Bureau, February, London, 2007.
21. Richardson, J., G. Harrison, and G. Parkhurst. *Public understanding of sustainable transport*. Department for Environment Food and Rural Affairs, November, London, 2007.
22. Rienstra, S.A., Rietveld, P. and Verhoef, E.T. The social support for policy measures in passenger transport: A statistical analysis for the Netherlands. *Transportation Research Part D: Transport and Environment* Vol. 4, 1999, pp. 181-200.
23. Anable, J., B. Boardman and A. Root. Travel Emission Profiles: A tool for strategy development and driver advice. *Environmental Change Unit Research Report No 17*, University of Oxford, 1997.
24. Brand, C. and B. Boardman. Taming of the few – the unequal distribution of greenhouse gas emissions from personal travel in the UK. *Energy Policy*, Vol. 36, 2008, pp. 224-238.
25. Greening, L.A. Effects of human behaviour on aggregate carbon intensity of personal transportation: comparison of 10 OECD countries for the period 1970–1993. *Energy Economics*, Vol. 26, 2004, pp. 1-30.
26. Greening, L.A., L. Schipper, R.E. Davis, and S.R. Bell. Prediction of household levels of greenhouse-gas emissions from personal automotive transportation. *Energy*, Vol. 22, 1997, pp. 449-460.