ARE PRICING POLICIES EFFECTIVE TO CHANGE CAR USE?

Geertje SCHUITEMA
Department of Psychology
University of Groningen
Groningen, The Netherlands

Linda STEG
Lecturer, Department of Psychology
University of Groningen
Groningen, The Netherlands

Charles VLEK
Professor Emeritus, Department of Psychology
University of Groningen
Groningen, The Netherlands

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The effectiveness of transport pricing was considered in two studies regarding intended changes in car use if pricing policies were implemented. In the first study, respondents kept a travel diary for four days, noting all their car trips. Next, they indicated to what extent various pricing policies would affect the trips noted in the diary. In the second study, respondents indicated their intention to change their car use for various types of trips if pricing measures were implemented. By using tailored questionnaires, accurate feedback was provided about the financial consequences of pricing for each respondent separately.

Results revealed that under pricing policies most people did not intend to change their car use. Pricing policies were relatively more effective when prices increased significantly. Especially visiting and shopping trips were affected, while commuting trips were hardly affected. Moreover, respondents were most likely to reduce their car use for short trips, which are an important source of CO_2 emissions and local air pollution.

Key Words: Pricing policies, Behavioural changes, Car use, Trip motive, Price level

1. ARE PRICING POLICIES EFFECTIVE IN CHANGING CAR USE?

It is widely believed that negative impacts of car use can and should be considerably reduced[1-4], for instance through sophisticated transport technologies. However, technical measures are not sufficient to reduce all negative impacts, because their environmental benefits are often overtaken by increasing car use. Therefore, behavioural changes to reduce car use are necessary as well. Various strategies for changing car use have been proposed[5-8], among which is transport pricing. In this paper, factors that may affect the effectiveness of such pricing policies are examined.

First, we consider which behavioural changes may occur when transport pricing is implemented (e.g., changes in transportation mode, route, or destination; research question 1 (RQ1)). Second, because some trips are likely to be more easily adapted than others[9], we consider how transport pricing would affect various types of trips (research question 2 (RQ2)). Third, the effectiveness of different types of transport pricing is examined; for important characteristics of pricing policies specific hypotheses are formulated below.

Various policy features may affect the effectiveness of transport pricing on car use. First, a distinction can be made between push and pull measures. *Push measures* are aimed at directly reducing the attractiveness of car use. In case of transport pricing this implies an increase in the costs of car use, for example increasing fuel taxes. *Pull measures* are aimed at increasing the attractiveness of alternative transportation modes, and, consequently, at making car use relatively less attractive, for example by decreasing costs for public transport (PT). Because of its many individual advantages (e.g., speed, flexibility and comfort), car use is preferred by the vast majority, even by people who mainly use alternative modes of transportation[10]. Therefore, it is not likely that pull measures alone can significantly decrease the relative attractiveness of car use, and thus car use itself. Indeed, a decrease in the costs of using PT appeared not to affect car use: new bus passengers were mainly those people who used to walk or cycle[11-12]. Therefore, our first hypothesis is that push measures are more effective in changing people's car use than pull measures (Hypothesis 1).

Second, price level is very likely to affect car use: it is expected that pricing policies are more effective when price changes are larger (Hypothesis 2).

Finally, the allocation of revenues from push measures may affect the effectiveness of transport pricing. Allocating revenues to benefit car users (e.g., by decreasing car-related taxes) appears to be more acceptable than allocating revenues to general public funds[13-14]. However, allocating revenues to car users undermines the initial purpose of the measure, that is, increasing the costs of car use. Therefore, we hypothesize that transport pricing is less effective in changing car use when revenues are 'returned to car users' instead of being allocated to general public funds (e.g., by decreasing labour taxes; Hypothesis 3).

Most psychological studies on the effectiveness of transport pricing policies do not measure actual changes in car use, but only the intention to do so. Intentions to change behaviour do not necessarily go along with actual behavioural changes, because people may not think through their consequences in much detail. The studies presented below also focus on subjects' intentions to change car use. Special care was taken to derive valid judgements on respondents' intentions to change car use. First, financial consequences of transport pricing policies for individual car users were determined. Second, respondents reported their current travel behaviour in detail, and indicated to what extent transport pricing policies would affect these trips.

2. STUDY 1

In Study 1 we examined the effectiveness of two significant characteristics of transport policies on people's intention to change car use: Push versus pull measures (Hypothesis 1) and small versus large price changes (Hypothesis 2). Furthermore, it was examined which behavioural changes are likely to occur (RQ1). Finally, effects of pricing on 12 different types of trips were examined (RQ2).

2.1 Method

2.1.1 Sample

The sample consisted of 58 respondents. Respondents possessed a driving licence and had access to a car. The sample was representative for the Dutch population[15], except for mean age, which was a bit higher than average. This was due to the fact that only car drivers (with minimum age 18) were interviewed.

2.1.2 Diary

Respondents registered all their car trips ('from A to B') in a travel diary from Thursday to Sunday. To facilitate respondents to recall specific trips for the later interview (see next Section), for each trip respondents noted departure time, starting point, trip length (in kms), trip purpose, arrival time and place, and whether they were the driver or passenger. The following trip purposes were distinguished: (1) returning home, (2) visiting someone, (3) work or education, (4) business, (5) going out, (6) sports, (7) recreation, (8) shopping (except for groceries), (9) bringing or picking up somebody, (10) holiday, (11) grocery shopping, and (12) other. For each day, a maximum of 8 trips could be registered. At the end of the diary, respondents indicated their gender, age, income, education, and household type.

2.1.3 Interview

Within a week after completing the diary, respondents were interviewed at their home in person or by telephone. Respondents were asked to indicate how an increase in fuel prices (push measure) and a decrease of PT fares (pull measure) would affect the car trips registered in the travel diary. Half of the respondents were first presented with the push measure, the other half first evaluated the pull measure. Between three subgroups, both measures varied systematically among a low, middle and high price level. For the push measure, fuel prices would increase by 5, 10 or 20 €cent per litre. For the pull measure, PT fares would decrease by 10, 20 or 50%. The total study design is given in Table 1.

For each trip recorded in the travel diary, respondents indicated whether and how they would change this trip if the push or pull measure, respectively, would be implemented. For the pull measure the response categories were (1) no change (i.e., sticking to the car), or changing transportation mode to (2) bus, (3) train, (4) tram, or (5) subway, instead of the car. For the push measure, these categories were extended with (6) going by

Table 1 Design and number of respondents per condition

		Push measure increase of fuel prices	N	Pull measure decrease of PT fares	N
Price level	low	5 €cent increase	22	10% decrease	18
	medium	10 €cent increase	18	20% decrease	21
	high	20 €cent increase	18	50% decrease	19

Note: Respondents were randomly assigned to a 'push' and 'pull' condition.

foot or (7) bicycle, (8) do not make the trip at all, (9) combine this car trip with other trips, or (10) change the destination of the car trip.

2.2 Results

2.2.1 Which car trips were made?

Altogether, respondents registered 777 trips during four days (Fig. 1). Unsurprisingly, most trips were made to return home from various destinations. Next, most trips were made for grocery shopping, work or education, and visiting. Trips to go out, holiday and recreation trips were infrequent. This distribution corresponds fairly well with the pattern of car trips made by the general Dutch population in 2003[16].

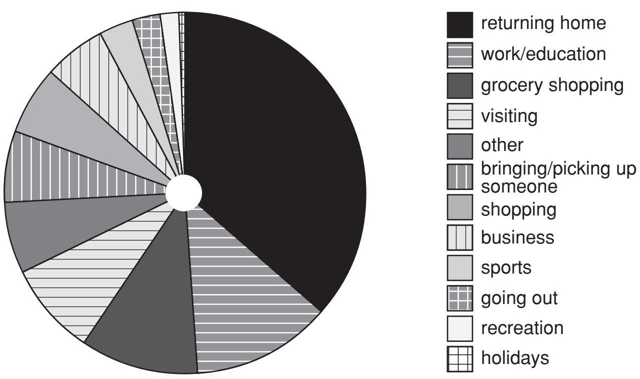


Fig. 1 Distribution of car trips as reported in travel diaries over 4 days, for 12 different trip purposes

2.2.2 Do people intend to change their car trips?

Of all car trips made (across price levels), respondents intended to change 2.6% (i.e., 20 car trips) if PT fares would be reduced. Increasing fuel prices would affect 5.3% of all car trips (i.e., 41 car trips). However, increasing fuel prices especially resulted in a reduction of short trips: 5.3% changed trips and 2% reduction of car kilometres; whereas a decrease in PT fares especially affected longer car trips: 2.6% changed car trips and 7.3% reduction of car kilometres. The overall difference between the number of changed car trips for push versus pull measures was not statistically significant ($t(57) = -3.4$, $p = 0.17$)[17].

2.2.3 Which types of car trips are changed?

As Figure 2 shows, respondents intended, across policies and price levels, to change car trips to return home most often. This is not surprising, since a car trip to return home is linked to an outgoing car trip serving another purpose. Next, car trips to go (grocery) shopping were most likely to be replaced. Car trips that respondents hardly intended to change were visiting trips, trips to go to work/ education, bringing/ picking up someone, business trips and "other" car trips. Since car trips for sports, recreation, going out, and holidays were hardly made (Fig. 1), it is not surprising that these types of trips were infrequently replaced.

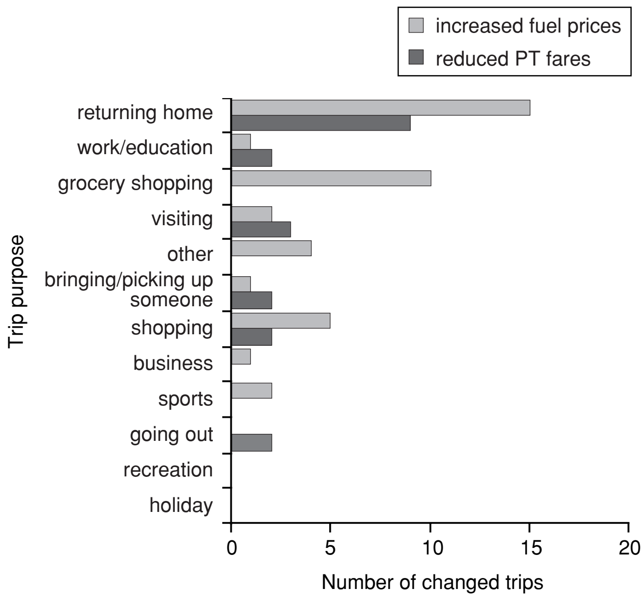


Fig. 2 Number of intended car trip changes when fuel prices increase or PT fares decrease, for 12 trip purposes, across 3 pricing conditions

2.2.4 Does price level affect people's intention to change their car use?

Figure 3 shows that the higher the increase in fuel prices, the more respondents intended to replace car trips ($F_{push}(2, 55) = 4.30$, $p < .05$)[18]. As part of the ANOVA, contrast tests were conducted to examine the differences between high, medium and low price changes separately. An increase of fuel prices with 20 €cent per litre led to more changes in car use than an increase with 10 €cent per litre ($t(18) = 2.93$, $p = .01$). No significant difference was found between increases of 20 versus 5 €cent per litre ($t(34) = 1.02$, $p = .31$). No significant difference was found between a 5 €cent price increase and a 10 €cent price increase either ($t(17) = -1.94$, $p = .07$).

In case of a reduction of PT fares, people tended to replace more car trips if fares were reduced more strongly ($F_{pull}(2, 55) = 2.55$, $p = .09$). Especially when PT fares were reduced by 50%, the tendency was that more car trips were replaced compared to a reduction of 20% ($t(19) = 1.77$, $p = .09$), but not compared to a fare reduction

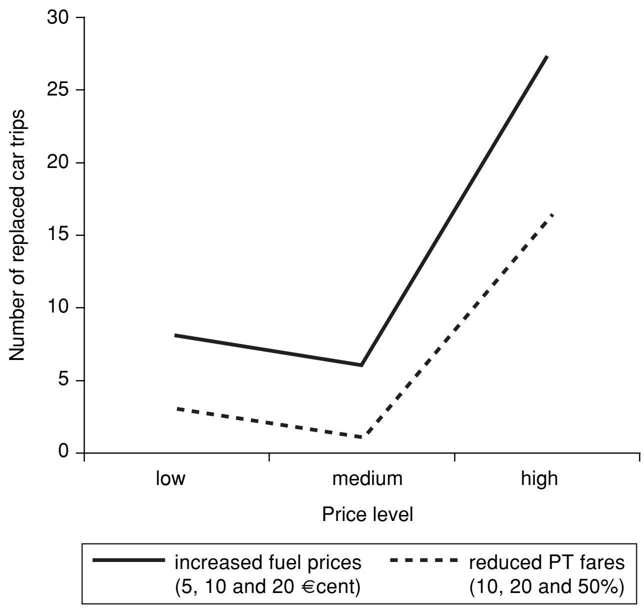


Fig. 3 Total number of replaced car trips of respondents for increased fuel prices and reduced PT fares for low, medium and high price level

of 10% (t (22) = 1.51, p = .15). No significant difference was found for the number of replaced car trips between a 10% and 20% reduction of PT fares (t (26) = −.57, p = .57)[19].

2.2.5 How do people intend to adapt their car trips?

Overall, most respondents intended to cycle or walk more often instead of driving their car when fuel prices would increase (Table 2). A few respondents indicated to use the train or to stop making the trip at all when fuel prices would increase. When fares of PT were reduced, respondents intended to travel more often by train and, to a lesser extent, by bus instead of by car.

Table 2 Replacements of car trips when fuel prices increase or PT fares reduce

Replace car trip by		Number of trips changed	
		increase fuel prices	decrease PT fares
change transport mode to	bus	0	6
	train	2	12
	tram	0	0
	subway	0	0
	walk	4	n.a.[a]
	cycle	30	n.a.
not make trip at all		5	n.a.
combine trips		0	n.a.
change destination		0	n.a.
total		41	20

[a] n.a. = not applicable

2.3 Discussion

In general, visiting and shopping car trips would be most frequently changed, whereas commuting car trips would be hardly changed (RQ1). When fuel prices were increased, people indicated to replace mostly shorter car trips by walking or cycling. When PT fares were decreased, mostly longer car trips would be replaced by trips made by train or bus (RQ2). Respondents tended to replace more car trips when fuel prices are increased than when PT fares are decreased. However, this difference was not statistically significant (Hypothesis 1), which may be due to the small sample size. Furthermore, the results indicate that a large price change would be more effective than medium and low price changes (Hypothesis 2).

3. STUDY 2

In Study 2, people's intention to change car use was examined when two types of kilometre charge were implemented. Changes in car use (RQ 1) were considered for three different trip motives (i.e., commuting, visiting and 'other' trips; RQ 2). Furthermore, the effect of price level (Hypothesis 2) and revenue allocation (Hypothesis 3) were examined.

3.1 Method

3.1.1 Sample

A computerized questionnaire survey was conducted among 562 Dutch car users selected from a larger telepanel of a Dutch marketing research institute. Of the total sample, 288 respondents were car users who experienced road congestion when travelling to work at least twice a week. Compared to the general Dutch car user, a majority of these drivers was male and had a relatively high income and educational level, which is typical for Dutch 'congestion drivers'[20]. The other 274 respondents were randomly selected from the total panel, provided that they had a driving licence and had access to a car. This group was representative for the Dutch population[15], except that the average age was somewhat higher, because the minimum age of Dutch car users is 18[21].

3.1.2 Procedure and design

Each respondent first evaluated a flat and then a variable kilometre charge. For both the flat and variable kilometre charge 6 versions were made, varying in price (3 levels) and revenue allocation (2 levels). Each respondent was randomly assigned to one version of the flat and one version of the variable kilometre charge. Below, both kilometre charges are described in more detail.

(1) Description of flat kilometre charge

The flat kilometre charge implied that car drivers had to pay for each kilometre driven by car. The charge could be either 3, 6 or 12 €cents per kilometre, while revenues were either used to reduce labour taxes or to reduce costs of car use (see left part of Table 3). It was made clear that the kilometre charge would be budget-neutral: revenues to benefit car users were either used to abolish road taxes (low km price), abolish road taxes as well as taxes on car purchase (medium km price), or abolish both these taxes as well as improving and building road infrastructure (high km price). Next, the estimated cost increases for each respondent were shown by multiplying the respondent's annual kilometrage by the price level of the charge. In case revenues were used to benefit car users, an estimation of the personal benefits was given as well, based on weight and fuel type of the car respondents used most frequently (for the calculation of the benefits, see Appendix). Also, total costs minus benefits were shown in case revenues were used to decrease costs for car users.

Table 3 Design and number of respondents per condition for flat and variable kilometre charge

		FLAT KILOMETRE CHARGE		VARIABLE KILOMETRE CHARGE	
		Revenue use to		Revenue use to	
		general public funds	benefit car user	general public funds	benefit car user
low price level	price	3 €cent/km	3 €cent/km	2 (o.r.h.[b]) versus 6 €cent/km (d.r.h.[c])	2 (o.r.h.) versus 6 €cent/km (d.r.h.)
	revenues	decrease labour taxes	abolish road taxes	decrease labour taxes	
	fin. conseq.[a]				
	costs	annual kms*3	annual kms*3	annual kms*2 (o.r.h.)/ annual kms*6 (d.r.h.)	annual kms*2 (o.r.h.)/ annual kms*6 (d.r.h.)
	benefits	n.a.	see Appendix	n.a.	n.a.
	total	n.a.	costs -/-benefits	n.a.	n.a.
	N	101	96	96	96
average price level	price	6 €cent/km	6 €cent/km	4 (o.r.h.[a]) versus 12 €cent/km (d.r.h.)	4 (o.r.h.[a]) versus 12 €cent/km (d.r.h.)
	revenues	decrease labour taxes	abolish road taxes and taxes on car purchase	decrease labour taxes	abolish road taxes and taxes on car purchase
	fin. conseq.				
	costs	annual kms*6	annual kms*6	annual kms*4 (o.r.h.)/ annual kms*12 (d.r.h.)	annual kms*4 (o.r.h.)/ annual kms*12 (d.r.h.)
	benefits	n.a.	see Appendix	n.a.	n.a.
	total	n.a.	costs -/- benefits	n.a.	n.a.
	N	94	91	94	91
high price level	price	12 €cent/km	12 €cent/km	8 (o.r.h.[a]) versus 24 €cent/km (d.r.h.)	8 (o.r.h.[a]) versus 24 €cent/km (d.r.h.)
	revenues	decrease labour taxes	abolish road taxes, taxes on car purchase and invest in road infrastructure	decrease labour taxes	abolish road taxes, taxes on car purchase and invest in road infrastructure
	fin. conseq.				
	costs	annual kms*12	annual kms*12	annual kms*8 (o.r.h.)/ annual kms*24 (d.r.h.)	annual kms*8 (o.r.h.)/ annual kms*24 (d.r.h.)
	benefits	n.a.	see Appendix	n.a.	n.a.
	total	n.a.	costs -/- benefits	n.a.	n.a.
	N	88	92	88	97

[a] fin. conseq. = financial consequences; [b] o.r.h. = outside rush hours; [c] d.r.h. = during rush hours
Note: Respondents were randomly assigned to one of the conditions of the flat and variable kilometre charge.

(2) Description of variable kilometre charge

The variable kilometre charge implied that higher prices were applicable during rush hours than outside rush hours (between 7.00–9.00 a.m. and 5.00–7.00 p.m.). Three price levels were distinguished: low (2 €cents/km outside rush hours versus 6 €cents/km during rush hours), medium (4 versus 12 €cents), and high (8 versus 24 €cents). Again, revenues were either used to reduce labour taxes or returned to car users (see right part of Table 3). Once more, it was made clear that the kilometre charge was budget-neutral, implying that revenues used to benefit car use were either used to abolish road taxes (low km price), abolish road taxes as well as taxes on purchasing cars (medium km price), or abolish both these taxes as well as improve and building road infrastructure (high km price). Next, an estimation of the cost increases was given. Since it was not known how many kilometres respondents drove during rush hours, total costs were indicated in case respondents would drive exclusively during rush hours (annual kilometrage was multiplied by km price during rush hours) and in case respondents would never drive during rush hours (annual kilometrage multiplied by km price outside rush hours). Only when revenues were used to benefit car users, an estimation of the benefits for the respondents was shown, as based on weight and fuel type of their most-used car (see Appendix).

3.1.3 Questionnaire

A computerized questionnaire was designed to examine the effectiveness and acceptability of four transport pricing policies. Below, the measurement of the effectiveness of the flat and variable kilometre charge are described in more detail[22-23].

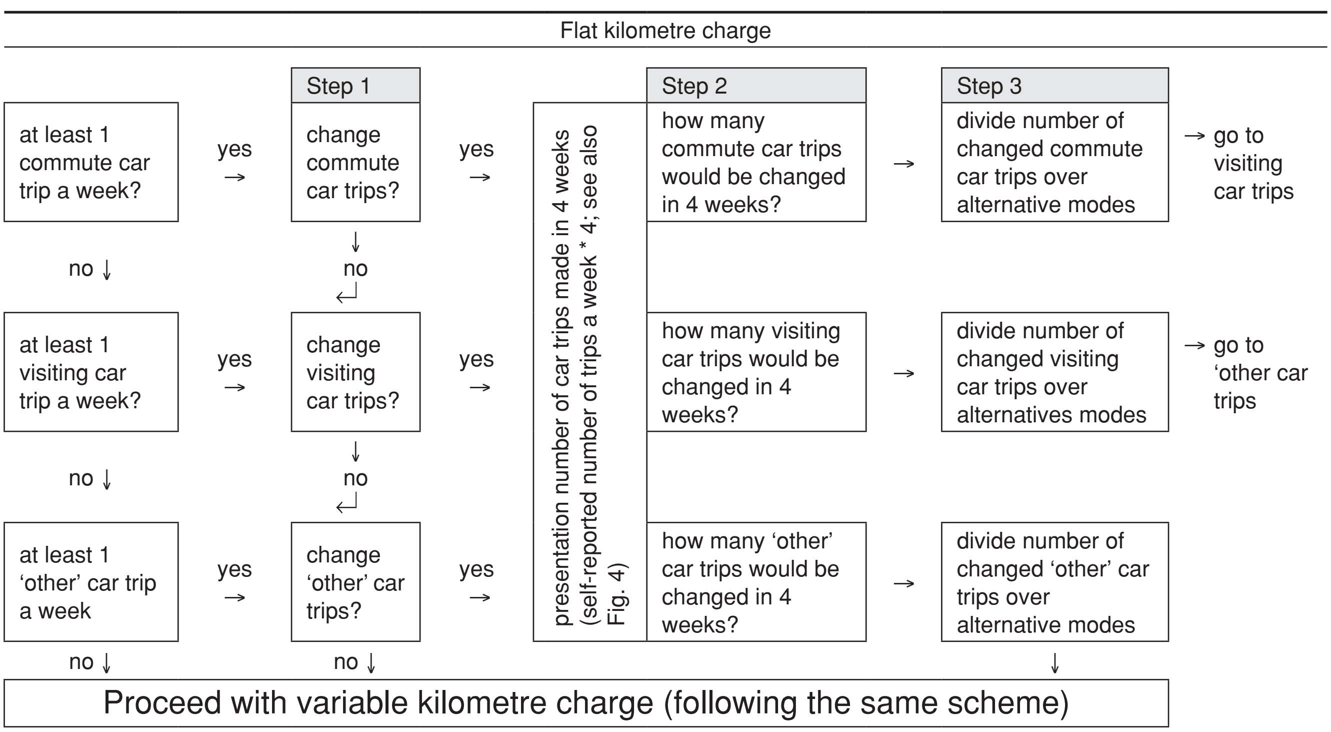
(1) Part 1: Current travel behaviour

Respondents indicated fuel type (petrol, LPG or diesel) and weight category (light, middle or heavy vehicle) for the car they used most frequently. Moreover, they indicated their average annual car kilometrage for private purposes (excluding business trips; M = 19,068 km). Next, they indicated which percentage of this kilometrage was used for commuting (M = 41.7%), visiting (i.e., go to see/ visit someone; M = 26.5%) and 'other' trips (i.e., all car trips except for commuting, business or visiting trips; M = 31.8%).

(2) Part 2: Effectiveness of flat kilometre charging

Respondents first evaluated the effects on their car use of a flat kilometre charge. Only those who had indicated before that they made one or more commuting car trips a week indicated their intention to change their commuting car use if the flat kilometre charge would be implemented. Subjects' intention to

Table 4 Flowchart representing the measurement of subjects' intention to change car use



change car trips was measured in three steps (see Table 4). Next, the same procedure was followed for visiting and 'other' car trips. Again, these questions were presented only to respondents who had indicated to make one or more visiting or 'other' car trips a week.

First, respondents indicated whether or not they would change their car trips when a flat kilometre charge would be implemented ((1) yes, change car use to avoid cost increase or (2) no, no change in car trips)[24]. Only respondents who indicated to change commuting trips (N = 395), visiting trips (N = 450) or 'other' car trips (N = 522) answered the more detailed questions about changes in these trips as explained below.

Second, respondents who had indicated to change their car use, estimated how many trips they would change for each purpose per 4 weeks. For this purpose, for each type of trip the self-reported number of car trips per week was multiplied by 4. The computed total number of trips made in 4 weeks was presented to the respondents to ensure that respondents would provide valid assessments, and to enable respondents to indicate small numbers of intended car trip changes. On average, 17 commuting, 7 visiting and 14 'other' car trips were made in four weeks.

Third, respondents indicated how they would replace the car trips that they intended to change. The alternatives were: changing transportation mode by using (a) PT, (b), non-motorized transport (e.g., walk, cycle), (c) other motorized transport (e.g., moped, motorcycle), (d) carpool, or (e) not making the trip at all. For commuting car trips the options (e) 'not making a trip because of a reduction of working days' and (f) 'working at home' were added.

(3) Part 3: Effectiveness of variable kilometre charging

Respondents evaluated the variable kilometre charge as described above. The questions and procedure were identical to the scheme followed for the flat kilometre charge, with one exception: in the third step, an additional alternative for intended changes in car use was added, namely (g) 'change travel times', since this option is highly relevant in case of time-dependent kilometre charging.

3.2 Results

3.2.1 Do people intend to change their car use?

When the flat kilometre charge was implemented, almost 11% of the respondents indicated they would change their commuting car trips, while a significantly higher percentage of about 25% would change their visiting (t (315) = 5.7, p < .001) and 'other' car trips (t (369) = 5.9 p < .001; Fig. 4). For the variable kilometre charge, the number of changed car trips did not differ for commuting, visiting, and 'other' purposes.

A paired t-test revealed that respondents intended to change their commuting car trips more often in case of a variable kilometre charge, compared to a flat kilometre charge (t (392) = 6.5, p < .001). For visiting and 'other' car trips, no differences were found between the flat and variable kilometre charge.

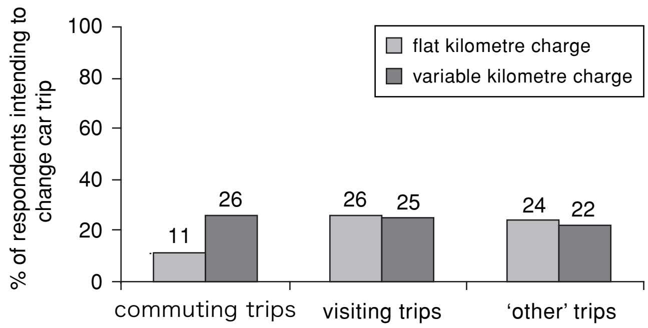


Fig. 4 Percentages of respondents who intended to change one or more commuting, visiting and 'other' car trips per four weeks

3.2.2 How many car trips would be changed by respondents who intended to reduce their car use?

Figure 5 represents the percentages of car trips changed in four weeks when the flat and variable kilometre charge would be implemented. Those who intended to change planned to change approximately half of these trips. Overall, respondents indicated to change mostly visiting and 'other' car trips.

The variable kilometre charge appeared to be more

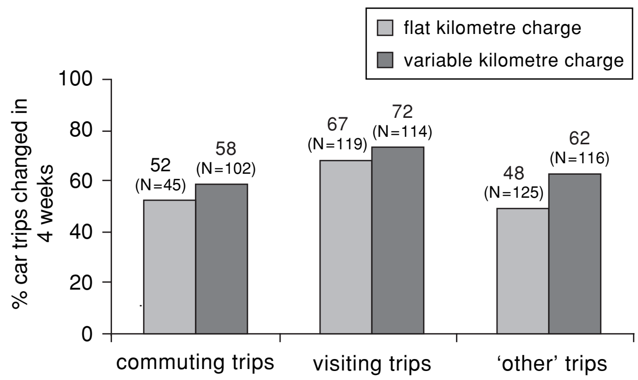


Fig. 5 Percentage of changed commuting, visiting and 'other' car trips made in 4 weeks by respondents who intended to change their car use

effective than the flat kilometre charge in changing the number of visiting ($t(62) = -2.2$, $p = .04$) and ‘other’ car trips ($t(66) = -2.5$, $p = .01$), while for commuting trips no significant differences were found.

3.2.3 How do people change their car trips?

Respondents who intended to change their car use would mostly switch to alternative transportation modes (notably PT and non-motorized transport; see Table 5) when the flat kilometre charge would be implemented. In this case, respondents rather frequently indicated to stop making visiting and ‘other’ car trips at all, whereas for commuting trips this option was hardly chosen. Replacing car trips by other motorized transport was not chosen frequently. For the flat kilometre charge, carpooling was an alternative for almost 20% of the commuting trips, whereas working at home was not often chosen as an alternative for commuting trips.

In case of a variable kilometre charge, respondents who intended to change their car use would, for almost half of these car trips change their travelling times. Also, respondents expected to switch to other modes of transportation (i.e., using PT and non-motorized transport) as well. Other motorized transportation as well as refraining from making a trip were hardly an alternative. In case of the variable kilometre charge, commuting car trips were hardly changed into carpooling or working at home.

3.2.4 Are changes in car use related to price level and revenue use?

Chi-square tests[25] were used to examine whether revenue allocation and price level were related to respondents’ intention (yes or no) to change their commuting, visiting and ‘other’ car trips. Obviously, analyses were only conducted for respondents who made these trips at least once a week. Results are presented in Figures 6a, 6b, 7a, and 7b.

For the flat kilometre charge, more respondents intended to change their commuting trips when revenues were allocated to decreasing labour taxes (16.8%) compared to when revenues were used to benefit car users (6%; $\chi^2(1) = 11.30$, $p < .001$). Revenue allocation was unrelated to intention to change visiting ($\chi^2(1) = 2.61$, $p < .106$) and ‘other’ car trips ($\chi^2(1) = .96$, $p < .327$).

The higher the price level of the flat kilometre charge, more people intended to change their visiting car trips ($\chi^2(2) = 9.97$, $p = .007$). When the price level was 12 €cent/km 33.8% people indicated to change their car use, 28.3% when the price level was 6 €cent/km, and 18.1% when the price level was 3 €cent/km. Price level did not significantly affect the number of respondents who intended to change their commuting ($\chi^2(2) = 7.73$, $p < .155$) and ‘other’ car trips ($\chi^2(2) = 3.71$, $p < .156$).

In case of the variable kilometre change, revenue allocation and price level did not affect respondents’ intention to change their commuting ($\chi^2_{revenue\ use}(1) = 3.0$, $p < .332$; $\chi^2_{price\ level}(2) = 1.11$, $p < .572$), visiting ($\chi^2_{revenue\ use}(2) = .96$, $p < .327$; $\chi^2_{price\ level}(2) = .90$, $p < .639$) and ‘other’ car trips ($\chi^2_{revenue\ use}(1) = .71$, $p < .399$; $\chi^2_{price\ level}(2) = 2.35$, $p < .309$).

3.3 Discussion

Results revealed that about 11% of the respondents under a flat and 26% under a variable kilometre charge would change their commuting car trips, while roughly 25% would change their visiting and ‘other’ car trips when kilometre charging would be implemented. Of those who intended to change their car use, most respondents would switch to other transportation modes, especially public or non-motorized transport (RQ1). For

Table 5 Percentage of changed car trips, divided over various alternatives for respondents who intended to change their car trips when a flat and variable kilometre charge is implemented

		N	Alternatives for changing car use						
			change travel mode to						
			PT	non-motorized transport	motorized transport	not making trip	change travel times	work at home	carpool
Flat km charge	commuting	45	31.7	32.3	9.5	0.5	n.a.[a]	6.5	19.5
	visiting	119	17.6	44.5	9	28.8	n.a.	n.a.	n.a.
	‘other’	125	13.3	64.8	1.8	19.9	n.a.	n.a.	n.a.
Variable km charge	commuting	102	17.7	12.7	8.8	0.6	47.8	7.9	4.5
	visiting	114	13.6	28	1.7	8.8	47.8	n.a.	n.a.
	‘other’	116	14.1	28.9	1.5	8.2	47.3	n.a.	n.a.

[a] n.a. = not applicable

Flat kilometer charge

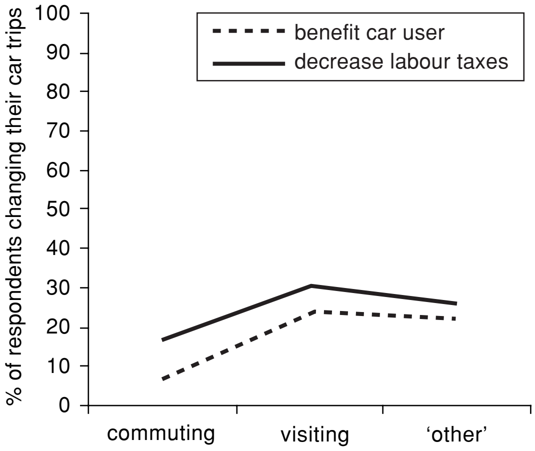


Fig. 6a Percentage of respondents who intended to change their commuting, visiting and 'other' car trips for two conditions of revenue allocation, when a flat kilometre charge is implemented

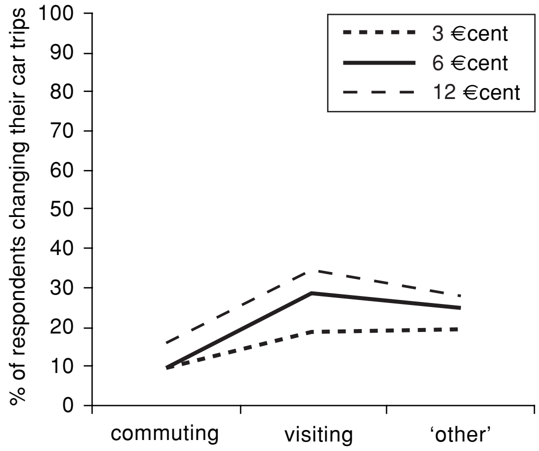


Fig. 6b Percentage of respondents who intended to change their commuting, visiting and 'other' car trips for three price level conditions, when a flat kilometre charge is implemented

Variable kilometer charge

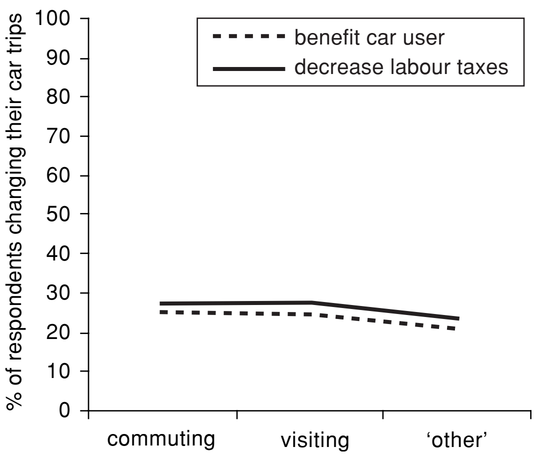


Fig. 7a Percentage of respondents who intended to change their commuting, visiting and 'other' car trips for two conditions of revenue allocation, when a variable kilometre charge is implemented

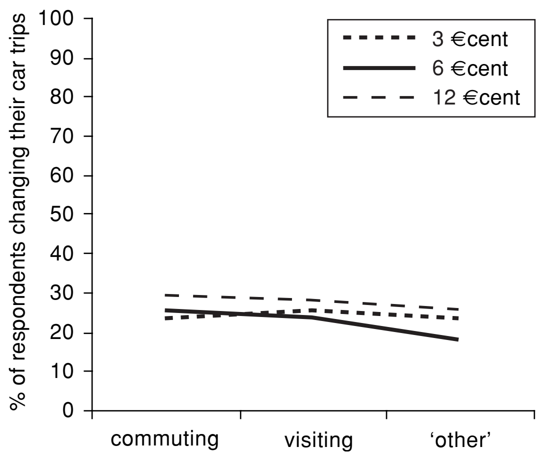


Fig. 7b Percentage of respondents who intended to change their commuting, visiting and 'other' car trips for thee price level conditions, when a variable kilometre charge is implemented

visiting and 'other' car trips, some respondents would stop making these trips at all. In case of a variable kilometre charge, respondents' also intended to change their travel times. This option was chosen for almost half of the trips that would be changed.

Respondents were likely to change more visiting or 'other' car trips than commuting trips (RQ2). Those who intended to change their car use would change approximately half of the number of trips usually made.

Hypothesis 2 was partially confirmed: higher price levels of the flat kilometre charge especially affected visiting trips, but not commuting and 'other' car trips. In case of the variable kilometre charge, no effect of price level on intention to change car trips was found.

Hypothesis 3 was partially confirmed: more people intended to change their commuting car trips when revenues of the flat kilometre charge were allocated to decrease labour taxes compared to when revenues were used to benefit car users. However, revenue allocation did not affect changes in visiting and 'other' car trips. Also, for the variable kilometre charge, revenue allocation had no effect on people's intention to change car use.

4. GENERAL DISCUSSION

In line with Jakobsson, Fujii and Gärling[26], it was shown that when costs of car use increased (either by increased fuel prices or by kilometre charges), shopping and visiting trips were affected most, whereas commuting trips were much less affected (RQ1). Instead of making trips by car, those people who changed their intended car use generally chose to travel by other modes of transportation such as public transport, walking or cycling (RQ2). When a price increase might be avoided by changing travel times (which fits a variable kilometre charge), this option was chosen most often. This is an interesting result: changing travel times seems to be perceived as a more feasible option than other alternatives, probably because it requires relatively little effort.

We also examined how policy characteristics were related to changes in car use. First, it was expected that push measures, reducing the attractiveness of car use, would be more effective in changing car use than pull measures (Hypothesis 1). Although the average extent of changes in car trips were in line with this expectation, differences were not statistically significant, possibly due to the relatively small sample size. Nevertheless, the results of Study 1 have some important implications. First, it appeared that lowering public transport fares (a pull measure) mainly reduced (a small number of) longer car trips. Second, an increase in fuel prices (a push measure) mainly resulted in a reduction of short car trips, which were often replaced by trips made by foot or bicycle. Despite the fact that the total kilometre reduction was rather small, these changes may significantly reduce (urban) traffic problems. Short car trips are often made in densely populated areas, causing relatively high levels of air pollution and other nuisance. Consequently, push measures may significantly contribute to improving local environmental quality.

Second, it was expected that large price changes would be more effective than small price changes (Hypothesis 2). Results of Study 1 revealed that a high increase of fuel price resulted in more car-use changes than low and average fuel price increases. However, in Study 2 the influence of price level on the effectiveness of kilometre charging was less clear. As in Study 1, for a flat kilometre charge more respondents intended to change their car use when the price per kilometre would be high, but this was found for visiting trips only. For the variable kilometre charge, price level appeared not to influence the effectiveness of the charge, which may have to do with the fact that a small kilometre price already had quite strong effects on car use; people could relatively easily evade the measure by changing their travel times. Thus, for some transport pricing policies small price changes may be rather effective, whereas for other policies, strong price increases may be needed to change car use; this seems to depend on the ease of behavioural adaptations (e.g., changing travel times versus changing transportation mode).

Hypothesis 3 was partly confirmed: in case of a flat kilometre charge, more people indicated to change their commuting car trips when revenues were allocated to decrease labour taxes compared to using revenues to benefit car users (i.e., abolishing fixed car taxes and/or improving road infrastructure). However, for other types of trip revenue allocation was not related to changes in car use. For the variable kilometre charge, people's intention to change car trips appeared not to be related to revenue allocation.

In summary, the results of both studies revealed that the effectiveness of transport pricing depends on various policy-relevant factors. When the aim of pricing is to reduce congestion, a variable kilometre charge may well cause significant changes in the travel times of commuter car drivers. However, when the aim is to reduce local air pollution or CO_2 emissions, a variable kilometre charge may be less effective, because the number of trips will be hardly reduced. In that case, introducing overall cost increases of car use (e.g., via a flat kilometre charge) may be more effective, because this would primarily affect the number of short car trips which are especially burdening in densely populated areas.

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17. A t-test was conducted to examine whether the average number of replaced car trips differed for the push and pull measure. The t-value indicates the ratio of the mean difference to the standard error of this difference.
18. An one-way analysis of variance (ANOVA) was conducted to examine the differences between the numbers of replaced car trips for three price-level conditions. The F-ratio indicates the ratio of the between-group variance to the within-group (or error) variance.
19. Since variances were not equal for all price conditions, t-tests that do not assume equal variances are reported. As a result of unequal variances, combined with a small sample size, the power of these t-tests is rather small, implying that is it less likely to find significant differences between price levels.
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22. For more information about the other two transport policies and the parts concerning acceptability we refer to Tillema, T. Road pricing: a transport geographical perspective. Geographical accessibility and short and long-term behavioural effects. Utrecht, Utrecht University (PhD-thesis). (2007).
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25. Chi-square tests were conducted to examine the distribution of the number of respondents for each price level and revenue allocation. The χ^2 indicates whether the frequencies per condition in the sample (*observed frequencies*) deviate from the frequencies that can be expected based on probability calculations (*expected frequencies*) in the sample.
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APPENDIX

Table to calculate benefits for car users when revenues of kilometre charges are used to abolish road taxes. The numbers are based on the road taxes that were in place in 2004.

Car weight /fuel type	Petrol	Diesel	LPG
light (<1000 kg)	€220	€550	€500
middle class (1000 – 1250 kg)	€350	€700	€700
heavy (>1250 kg)	€550	€1100	€1100

Calculation of the benefits for car users when revenues of kilometre charges are used to abolish road taxes and taxes on the purchase of cars. The numbers are based on taxes that were in place in 2004.

Car weight /fuel type	Petrol	Diesel	LPG
light (<1000 kg)	€520	€1150	€800
middle class (1000 – 1250 kg)	€850	€1400	€1200
heavy (>1250 kg)	€1200	€2000	€1750