Design elements of road pricing schemes and their acceptability

Milenko VRTIC
Institute for Transport Planning and Systems (IVT)
ETH Zurich, HIL F 51.1
CH-8093 Zurich
Phone: +41-44-633 31 07
Fax: +41-44-633 10 57
Email: vrtic@ivt.baug.ethz.ch

Nadine SCHUESSLER
(Corresponding Author)
Institute for Transport Planning and Systems (IVT)
ETH Zurich, HIL F 51.1
CH-8093 Zurich
Phone: +41-44-633 30 85
Fax: +41-44-633 10 57
Email: schuessler@ivt.baug.ethz.ch

Alexander ERATH
Institute for Transport Planning and Systems (IVT)
ETH Zurich, HIL F 51.1
CH-8093 Zurich
Phone: +41-44-633 30 92
Fax: +41-44-633 10 57
Email: erath@ivt.baug.ethz.ch

Kay W. AXHAUSEN
Institute for Transport Planning and Systems (IVT)
ETH Zurich, HIL F 51.1
CH-8093 Zurich
Phone: +41-44-633 39 43
Fax: +41-44-633 10 57
Email: axhausen@ivt.baug.ethz.ch

Words:	6312
Figures:	3 (=750 words)
Tables:	3 (=750 words)
Total:	7812

ABSTRACT

One key factor for the successful introduction of a road pricing scheme is its electoral acceptability, which is in turn strongly affected by its design. This is even more true in Switzerland, where any major policy change has to be approved by a majority of the voters in a referendum. An extensive stated preference (SP) survey about the acceptability of different design elements was included in a study about the impact of possible transport pricing schemes on passengers' travel behaviour conducted on behalf of the Swiss federal government. The results of the acceptability survey are presented in this paper.

The aim of the study was to assess the influence of various scheme elements on acceptability. The proposed charging level is the most important factor. Distance-based motorway tolls and km-dependent tolls for all roads are the preferred pricing types, in contrast to area licensing and time-dependent tolls. In connection with the discussion on the use of the revenues, replacing the existing pricing mechanisms, the fuel tax and motorway vignette, was the least liked option even though it would lower costs for the individual. However, the most favoured alternative is investment in public transport, followed by reductions in income tax and a bonus-malus system that redistributes the revenues directly back to the Swiss population.

INTRODUCTION AND MOTIVATION

In Switzerland, a broad political discussion about the introduction of road pricing schemes has started. Facing potentially shrinking funding streams in the long run, new instruments have to be found to maintain funding, but also to shift travel demand in time and space to a more efficient utilisation of the existing transport infrastructure. In addition, there is an increasing desire to allocate infrastructure costs by usage, as already implemented with the mileage charge for trucking (1) and for motorway use with the annual vignette, though this turned out to be unsatisfactory with regard to demand management (2). A variety of experiences abroad indicate that road pricing can be an efficient way of achieving these aims (e.g., 3 and 4).

One key factor to a successful introduction of a road pricing scheme is its social and political acceptability. This is especially true in a direct democracy like Switzerland, where a referendum has to be held before a legislative measure such as a road pricing scheme can be introduced. Thus, the Swiss federal government has to take into account the acceptability of the road pricing scheme before presenting it to the public. The acceptability in turn is strongly affected by the design of the scheme. Even though this is widely known, to date no detailed examination of the influence of different design elements on the acceptability has been undertaken in Switzerland; and only rarely elsewhere (5 and 6).

The Swiss federal government has asked the Institute for Transport Planning and Systems (IVT), ETH Zurich, in collaboration with the Transport and Mobility Laboratory (TRANSP-OR), EPF Lausanne and the Institute for Economic Research (IRE), USI Lugano, to carry out a study about the possible impact of different transport pricing schemes on individual transport behaviour. In the course of this project, a number of stated preferences (SP) surveys were undertaken, one of which was about the acceptability of and the political attitude towards road pricing schemes. The consequent SP experiments evaluated the changes of the traveller's behaviour regarding route, mode and departure time choices. The results of this analysis are presented in a parallel paper (7). The complete project is presented in (8).

In the SP experiment about acceptability, the participants were presented with road pricing schemes that were characterised by various design elements, such as the type of the road pricing, the cost level or the use of the revenues - to name just a few. The experiment had two major objectives: One was to see if they would forego using this as an opportunity to make a political statement and give their genuine most likely reaction in the following SP experiments. Two, it was designed to measure the influence of the various design elements on the political acceptability of a road pricing scheme.

Thus, the answers contributed to two different analyses. First, they were considered as inertia variables in the modelling of the impact of new pricing schemes on traveller’s choice of route, mode and departure time (7). Second, they were analysed in their own right to explore the impact of different design elements on the overall acceptability of a possible scheme. It should be noted though, that the objective of the overall study was to assess the responses of the public in terms of route, mode and departure time choices. The stated preference of acceptability is not the focus of the study, but rather a collateral benefit.

This paper discusses the results of the latter analysis. It starts with a survey of preceding acceptability studies of road pricing. The design of the study is described and the derived acceptability model

presented. The paper concludes with the implications for the design of an acceptable road pricing scheme.

ROAD PRICING AND ITS ACCEPTABILITY

There is a broad consensus that acceptability is crucial for the introduction and operation of road pricing measures and certainly has to be evaluated by local authorities who intend to introduce such schemes. Several recent attempts failed as a result of the lack of political acceptability, for example, Edinburgh (9), Copenhagen and the Netherlands (10). The examples emphasise the need to understand how the acceptability of road pricing schemes could be influenced.

However, before starting an analysis of acceptability, a short definition of the term is required. (6) defines acceptability as 'the prospective judgement of measures to be introduced in the future, while acceptance is defined by the respondents' attitudes after the introduction'. Acceptability is influenced by several factors that can be grouped into measure-related factors and person-related factors. An important paradox is the difference between public acceptability of road pricing measures and experts' appraisal of their effectiveness. In contrast to transport planners and economists, who increasingly favour road pricing as an instrument to solve today's transport problems, the public is still quite sceptical about road pricing measures. This has been shown in several acceptability studies as reported by (11) and (12). To understand this paradox, we have to examine the person-related factors affecting acceptability.

The EU-funded AFFORD project (11) indicates that attitudes towards road pricing vary with the modal distribution of commuters. It was shown that the preferred transport mode is the only socioeconomic variable that had a statistically significant influence on the willingness to accept urban road pricing. (13) report similar results from a study of public acceptability of road pricing schemes in two UK cities. Based on results from a regression model for predicting voting behaviour, they predict that 18.6% of car users would be willing to accept a scheme involving a £3 daily charge, in contrast to 46% of the non-car users. These figures are similar to those obtained in the 2004 opinion poll in Stockholm (14).

In addition, the social dilemma of self-interest against social-interest is fundamental. In contrast to classic economic theory, there is much evidence, even provided by (15), that individual preferences are not only derived from their personal well-being. Nevertheless, (16) demonstrated that benefits for the individual are more than three times as important to them than benefits to society. Furthermore, they showed that persons who believe in the effectiveness of a road charging scheme are more likely to see a social benefit from the measure and therefore support it.

Besides these two factors, (17) identified a third personal factor that strongly influences the acceptability of road pricing measures: social norms. Since most people strive for social integration and consonance (18) the pressure towards conformity exercised by relevant others is one of the strongest factors influencing personal opinions, feelings and behavioural intentions. However, these influences may go in either direction, depending on the general attitude towards road pricing present among the public.

In addition, if the economic theory that high income groups have a lower marginal utility of money and therefore support such measures more than low income groups is assumed to be correct, then it

may also be assumed that acceptability of road pricing schemes depends on socioeconomic status. However, (19) found that the income level had no significant impact on support for the scheme and that the lowest income group perceived pricing as most effective measure. From further examination of the relationship between other socioeconomic variables and support, problem awareness and perceived effectiveness can be summarised as follows: The support for policy measures is influenced to a lesser extent by the personal features of respondents than by the perception of the problem (both at the individual and the social levels), the perceived effectiveness of a measure, and the type of measure (e.g., price measures).

A further distinction between factors influencing the acceptability of road pricing is provided by (20). He describes the so-called push and pull measures. Measures that are restrictive and reduce people's freedom of choice are called 'push' measures intended to make car usage less attractive. In contrast, 'pull' measures aim to stimulate the demand for other transport modes by making them more attractive. Empirical evidence shows that, in contrast to expert appraisal which favours push measures, public opinion perceives pull measures to be most effective. (5), a survey that asked what respondents thought the most effective solution for reducing traffic levels in London would be, demonstrated that, overall, pull measures are preferred. The pull measures 'better quality of public transport' (33%) and 'cheaper public transport' (18%) were seen as the most effective. Road user charges (£5 Central London) was chosen by only 5% of the respondents as the most effective approach. Similarly, (21) found 'improvements in public transport' to be the best-supported instrument. Since there is a strong correlation between perceived effectiveness and the acceptability of a measure (22), the conclusion can be drawn that acceptability of road pricing schemes can only be achieved by incorporating pull measures. This finding is also supported by (23) who noticed that the acceptability of a charge for driving on congested roads at peak times nearly doubles if the revenues are used to improve public transport.

The acceptability of different push instruments has been the focus of other studies (24 and 20). In these studies, parking-related measures such as reducing parking space or increasing parking costs have been the least disliked, followed by tolling strategies. Additional taxes (car ownership, petrol) are unacceptable to the vast majority.

STUDY DESIGN AND DATA COLLECTED

The core element of the study conducted for the Swiss government was a number of paper-and-pencil, self-administered stated preferences (SP) experiments. The participants were not only asked about their acceptance of road pricing but also about their route, mode and departure time choices in the presence of road pricing. Overall, each respondent received three SP experiments, the first one being about their preferences regarding different road pricing schemes. They also received two of the three further SP experiments on route, mode, and departure time choices under pricing schemes. The respondents were recruited as part of an on-going nationally representative survey conducted by the Swiss Federal Railroads (25). A sample of 2290 persons received the survey and the questionnaires were returned by 1005 respondents. The resulting response rate of 44% is high for such an extensive

and complex survey, which is certainly due to the pre-selection of the participants in the course of the Swiss Federal Railroads study.

Stated preferences surveys have been widely used to assess people's behaviour in hypothetical choice situations. With the help of SP experiments, the influence of specific variables on choice behaviour can be examined in detail. Of the variety of SP survey methods available, the stated choice formulation has been used here. Each respondent is presented with a certain number of alternatives that are described by different attributes and has to choose one of them. The SP experiments used here were formulated as referendum questions (referendums are held in Switzerland for all major political decisions). Just as in a real referendum, the respondents had to choose between the existing system and a new road pricing scheme, which was specifically presented in the choice situation. An example of such a choice situation is given in FIGURE 1. Overall, each respondent was confronted with six of these choice situations. An overview of the variables and their attribute values describing the road pricing alternative can be found in TABLE 1. These variables and the current Swiss system are described below.

	Current system	*Road pricing system*
Type of road pricing	Fuel tax, motorway vignette	Km-dependent toll
Cost	0.06 CHF/km	0.11 CHF/km
Use of the revenues	Road infrastructure Federal government budget	Road infrastructure Abolition of fuel tax and motorway vignette Reduction of income tax
	Average speed during peak hours	
Motorways	85 km/h	120 km/h
Country roads	45 km/h	55 km/h
City roads	30 km/h	30 km/h

❑ ← Your Choice → ❑

FIGURE 1 Example of a choice situation about political acceptability.

The Swiss case

Switzerland is a relatively small but densely populated country in the middle of Europe with extreme topographical differences. Thus, the settlement structure as well as the transport infrastructure are strongly influenced by its topographical features. In spite of this – or because of it – Switzerland has one of the world's densest transport infrastructures, for public transport as well as private transport. Due to its geographical position, Switzerland is a main European transit country, particularly for private transport. This increases its congestion problems, which is one of the reasons for the present discussion about the introduction of road pricing.

Currently, a simple type of road pricing already exists. As in most European countries, fuel taxes make up about half the retail price of fuel. The current tax level per km of 0.06 CHF/km was calculated using the September 2005 gas price and the average fuel consumption of the Swiss car fleet in 2004. In addition, each car driver who wants to use Swiss motorways has to buy a one-year vignette (window sticker) for 40 CHF. The revenues raised by the fuel tax and the vignette are spent on the expansion and maintenance of the road infrastructure. However, a certain amount of the revenues go into the general fund of the federal budget.

The road infrastructure is heavily used and congestion is a major issue resulting in low average speeds during peak hours. Though the maximum speed on motorways is 120 km/h, on average, only a speed of 85 km/h can be reached in peak hour traffic conditions. (See 26 for GPS-based floating car measurements.) For other types of roads, the situation is similar: within the cities, the average peak hour speed is 30 km/h and on other roads, in particular rural roads, 45 km/h.

Furthermore, to reflect Swiss political reality, a "sponsor of the bill" for the road pricing scheme is presented to each participant. In Switzerland, a positive referendum requiring the government to act can be initiated by any group able to collect the necessary quorum of 50,000 signatures. The same applies to a negative referendum to reject a bill passed by the parliament. In contrast to the other variables, the "sponsor of the bill" was not varied in the six situations of an SP experiment. For each participant, a randomly chosen sponsor and his motivation were presented in the cover letter and remained the same throughout the experiment.

As depicted in TABLE 1, a total of three sponsors and their motivation were presented. It was stated that the federal government aims to find new, usage-dependent ways to finance the road infrastructure and to solve the fundamental congestion problem and therefore suggests a road pricing scheme. The motivation for the automobile clubs to propose a road pricing scheme is similar: They doubt that the available financial resources are sufficient for an effective expansion of the road infrastructure and they seek a way to reduce congestion. The envisaged aim of the environmentalists is also better regulation of the transport demand, but they also want to internalise the external costs caused by drivers.

TABLE 1 Variables of the road pricing scheme

Variable	Attributes
Sponsor of the bill	Federal government, automobile clubs, environmentalists
Type of road pricing	Motorway toll, area licensing, km-dependent toll, time-dependent toll
Toll [CHF/km]	0.045, 0.075, 0.105, 0.15 CHF/km*
Use of the revenues	Road infrastructure and two of the following: 1. Abolition of fuel tax and motorway vignette 2. Bonus-malus system 3. Investment in public transport 4. Reduction of income tax
Average speed on motorways during peak hour [km/h]	85, 100, 120 km/h
Average speed on rural roads during peak hour [km/h]	45, 55, 65 km/h
Average speed on urban roads during peak hour [km/h]	30, 35, 40 km/h

(*) Currency exchange rate: 1 CHF = 0.80 USD (11/15/2006)

The first attribute presented to the respondents is the type of road pricing. The four different types are also explained in the cover letter: The motorway toll would replace the yearly vignette and motorists would be charged for the distance actually driven on Swiss motorways. In contrast, the km-dependent toll would account for all kilometres driven per year, independent of the type of road. The time-dependent toll would be applied to main roads and vary during the day, whereas the proposed area licence system would be similar to the Norwegian cordon pricing schemes, but without any time-of-day dynamics. No combinations of these pricing types were taken into account to reduce the complexity for the participants, though several combinations have shown to be very efficient. Likewise, there were no specifications concerning the implementation of the pricing schemes, e.g., in which cities area licensing would be applied.

Since it has been demonstrated that the proposed use of the revenues is an important factor for the acceptability of a road pricing schemes, four different kinds of revenue use plans were defined, two of which were presented in each choice situation. The abolition of the fuel tax and the motorway vignette, the reduction of income tax, and the investment in public transport are self-explanatory at this aggregate level. However, the bonus-malus system had to be explained in the cover letter. In this system, all revenues are collected by means of the road pricing schemes described above. However, afterwards, an equal amount of money is redistributed to each resident Swiss adult. Thus, at the end of the year, those who did not drive much receive a bonus, whereas others who travel more are subject to a malus.

TABLE 2 details the socio-demographic characteristics of the respondents and compares them to the overall sample of the Swiss Federal Railroads study, from which the sample was recruited. The figures demonstrate that the adult Swiss population is just as well represented here as in the SBB study, though there is a shift to 'male', ‘better paid’ and 'employed public transport users', which was already detected by (27). Persons younger than 18 were not included in the survey because this is the minimum age for a car driving licence in Switzerland. Still, these shifts were so small that no

reweighting was necessary. However, 14.7% of the respondents did not answer the question regarding household income. For those persons, an Expectation-Maximisation Missing Value analysis was conducted using SPSS software to compute the missing income values. The analysis took into account the respondents' employment status, car ownership, age, household size, sex and other available characteristics, such as the level of education and place of residence.

TABLE 2 Socio-demographic characteristics of the respondents

Characteristic	Level	Frequency	Percentage	SBB study
Gender	Male	558	55.5	50.9
	Female	447	44.5	49.1
Age	Younger than 25 years	95	9.5	11.8
	Between 25 and 45 years	381	37.9	40.5
	Between 45 and 65 years	405	40.3	36.7
	Older than 65 years	124	12.3	11.1
Language	German	818	81.4	78.5
	French	141	14.0	17.5
	Italian	46	4.6	4.1
Household income	Less than 36,000 CHF per year	37	3.7	4.4
	Between 36,000 and 72,000 CHF per year	202	20.1	23.8
	Between 72,000 and 108,000 CHF per year	327	32.5	30.1
	More than 108,000 CHF per year	291	29.0	24.7
	No answer	148	14.7	14.6
Employment	Full-time	504	50.1	51.4
	Part-time (less than 37 h/week)	209	20.9	20.7
	Unemployed	292	29.1	27.9
Car availability	Always	672	66.9	64.4
	Occasionally	205	20.4	20.4
	Never	128	12.7	15.1
Public Transport Subscription	General Abonnement (GA)	161	16.0	13.1
	Half-Fare Card (HT)	435	43.3	41.6
	No Subscription	409	40.7	45.3
Residential area	Cities	154	15.3	15.4
	Urban agglomeration	250	24.9	25.0
	Smaller agglomerations	277	27.6	27.4
	Rural areas	324	32.4	32.2

Regarding the spatial distribution, it can be seen that the different Swiss language regions have also been well covered, though the willingness to respond has been slightly higher in the German-speaking areas. All participants received the questionnaires in the primary language of their home location.

Yet another important characteristic is the ownership of mobility tools, since it has a prominent influence on transport behaviour. Mobility tools comprise all those things that reduce the marginal cost of use for one or more transport modes. Typical examples are car or public transport season ticket ownership. In this study, the two most important Swiss public transport subscriptions have been taken into account: the General Abonnement is a national annual ticket that allows its owner to use nearly all public transport services in Switzerland except a few mountain railways. The Half-Fare Card grants a 50% discount on the same services. Concerning the availability of a car, with 12.7% the proportion of respondents who have never access to a car is rather low in comparison to the Swiss mean. But this is certainly due to the nature of the study.

The last interesting characteristic of the respondents is their respective place of residence. In particular with regard to the acceptability of road pricing measures, it can be assumed that there are different preferences between respondents living in cities and those living in the countryside. The places of residence were classified into four categories. Again the figures show that the respondents reflect the overall Swiss pattern well, with 40.2% living in bigger cities and their agglomerations, 27.6% living in middle- and small-size towns and their agglomerations and 32.4% living in rural areas.

ANALYSIS AND RESULTS

From the 1005 respondents, each of whom received six choice situations, 5910 usable observations were obtained. Overall in 49.8% of the answers road pricing was chosen. This shows that the Swiss public does not systematically oppose road pricing. But public opinion is still sceptical and the acceptability of a road pricing scheme would strongly depend on its design characteristics.

FIGURE 2 illustrates the relationship between the sponsor of the bill, the road pricing type and the acceptance by the respondents. Similar patterns can be seen for the different sponsors. There is a high approval rate for a motorway toll and a km-dependent toll and less consent for an area licensing or a time-dependent toll. A reasonable explanation for this preference pattern is that motorway tolls and km-dependent tolls represent simple, straightforward, comprehensible and familiar ways of pricing. Motorway tolls are already well-known from France or Italy and it is intuitive that someone has to pay if he wants to drive on the quicker motorway. A km-dependent toll is seen as an effective measure to reduce the overall amount of car traffic and all the problems associated with it, particularly congestion. In contrast to that the explanation of the area licences and the time-dependent toll was not very specific in the questionnaire. Neither the areas nor the times to which these would be applied were defined for this national sample. Maybe these options were too global and abstract.

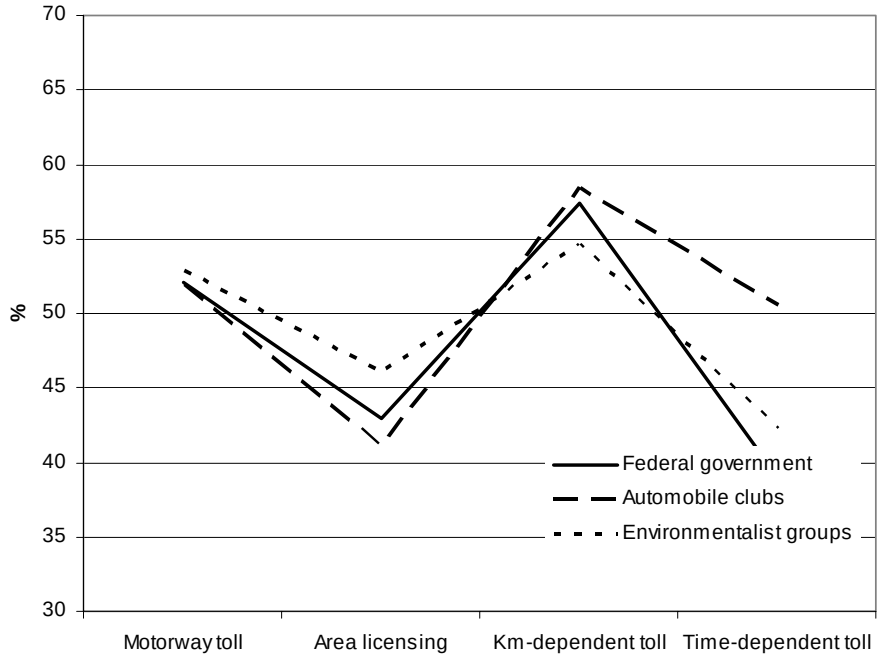

FIGURE 2 Supporters and opponents by type of road pricing and sponsor

Despite the largely similar patterns for the different sponsors, there were still some differences. If the sponsor was a coalition of environmentalists, the respondents are more likely to agree to area licensing. This is possibly due to the motivation associated with this sponsor in the questionnaire. The most important aim of the environmentalists is the reduction of external costs such as congestion but also noise or pollution. These are, to a certain extent, local phenomena and could be reduced best by means of an area licensing scheme. A time-dependent toll is preferred significantly more frequently when suggested by automobile clubs. This type of road pricing is seen to be effective in reducing peak hour congestion, which is an important aim of the automobile clubs.

Another interesting aspect is the influence of the respondent's place of residence on the preferred road pricing type. The same analysis as shown in FIGURE 2 was conducted for FIGURE 3, but this time using the four residential area categories: large cities, agglomerations around large cities, middle- and small-sized towns and their agglomerations, and rural areas. As one might expect, the inhabitants of the cities dislike area licensing more than other road pricing types. Since area licensing is more likely to be installed in cities, these respondents fear the individual costs of this method of pricing. However, they agree to all other types of pricing by more than 50% and not much difference can be seen between the preferences for them.

Respondents living in the agglomerations of the big cities only prefer road pricing by a percentage of more than 50% if the pricing is installed as a motorway toll. The other types of road pricing do not find much assent, least of all area licensing. The respondents living in the agglomerations mainly commute to their work places in the cities. They often depend on their cars and thus could neither avoid the area licensing nor the time-dependent toll which would probably be installed during peak commuting hours. Furthermore, they have high km-driven-per-year and therefore dislike the km-dependent toll. Similar patterns apply to the respondents living in rural areas, though they consent to none of road pricing approaches by more then 50%.

The only respondents that show high approval rates for all types of road pricing are those living in middle- and small-sized towns and their agglomerations. They chose all road pricing types with a majority of more than 55% and like the area licensing even better. Road pricing would probably not affect their commuting trips to the same degree as those of the other groups and thus not be inescapable, but, it presumably would influence their leisure and shopping behaviour.

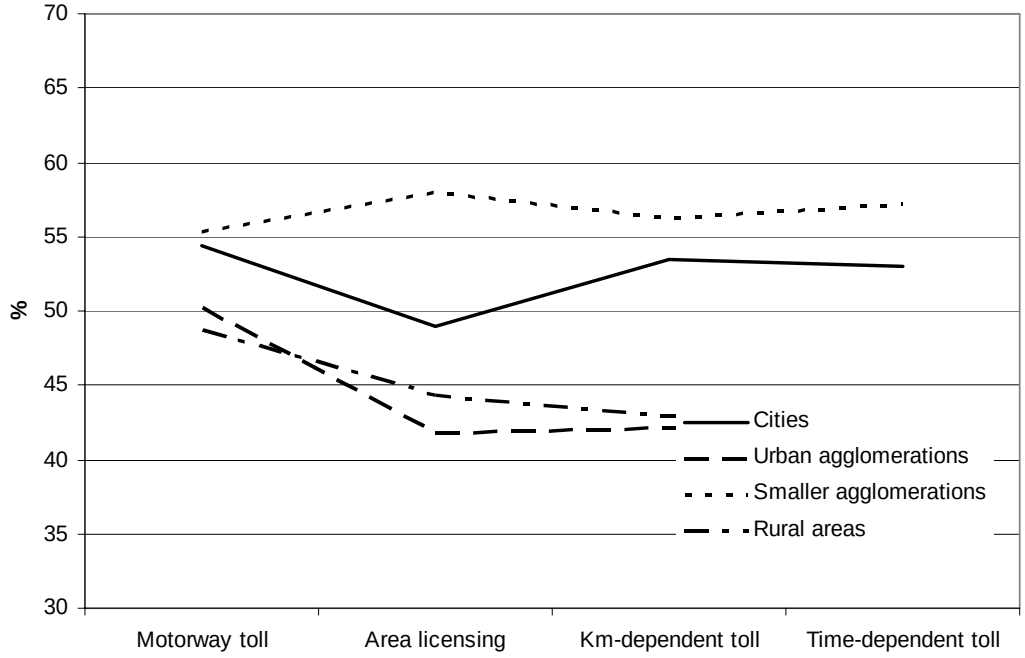

FIGURE 3 Supporters and opponents by type of road pricing and residential area.

The same type of analysis has been conducted for the sponsors and the envisaged use of the revenues. The differences are much smaller here. The percentage of pro-road-pricing answers is always close to 50%. In the questionnaire, a combination of two purposes for revenue use was presented. As in the model estimation described below, the two purposes can be treated as individual variables with the same parameters. Thus, the percentages of pro-road-pricing answers was calculated using both variables. Small but interesting differences in the preferences for the revenue use can be observed.
If the road pricing scheme is suggested by the federal government, then the preferred options for revenue use are a bonus-malus system and a reduction in the income tax. The bonus-malus system especially is a simple and elegant way of allocating the cost in a fair and usage-dependent way and to give further incentives to reduce personal car mileage per year. Regarding the reduction of income tax, the federal government is the only sponsor that can achieve this.
For the same reasons as mentioned above, the bonus-malus system is preferred by respondents who were presented with other sponsors. But in contrast to the first group, they also show high approval for road pricing schemes in which the revenues are invested in public transport. As explained earlier, investments in public transport are generally perceived to be the most effective pull measures for reducing congestion. Therefore, they increase the acceptability of road pricing schemes (see 28 or a possible reason for this perception).

The very interesting results demonstrate the influence of the characteristics of a road pricing scheme on its acceptability. Nevertheless, they only show two aspects at a time and might not reflect all factors. The observed choices can be modelled within a discrete choice framework in order to account for all variables at once. The main assumption here is that each decision-maker seeks to maximise his personal utility and accordingly chooses the alternative with the highest utility for him. The utility of

an alternative is defined by its utility function with an observed part V_i and an unobserved random part ε_i:

$$U_i = V_i + \varepsilon_i = \beta * x_i + \varepsilon_i$$

The observed utility can be described by a vector β_i of taste parameters and a vector x_i containing the attributes of the alternative and the socio-demographic characteristics of the decision-maker. The assumed distribution of the random parameters defines the model structure and thereby the functional form of the choice probabilities. The most commonly used formulation, also used here, is the Multinomial Logit (MNL) model, introduced by (29) and extended by (30). In this formulation, the error terms are independently distributed type I extreme values (Gumbel). The observed utility is, in absence of other plausible assumptions, assumed to be linear in the parameters. The software BIOGEME (31) was used for model estimation. The results of the model estimation are presented in TABLE 3. The model was estimated with consideration for the so-called panel effect, which accounts for the unobserved utility of the individual respondents. It is implemented with a normally distributed random term.

The most important factor for the acceptability of a road pricing scheme is the toll level of the pricing scheme. As one would expect, the acceptability decreases with increasing cost levels. The different types of road pricing have been coded as dummy variables with area licensing as the base alternative. There is a significant preference for the motorway and km-dependent tolls in contrast to area licensing, with km-dependent toll being the most favoured pricing type. Between the time-dependent toll and area licensing no significant difference could be found. The alternative usages of the revenues were also coded as dummy variables. Here, the base case is abolition of the fuel tax and motorway vignette, which is the least liked alternative. Highest preference is given to investments in public transport, followed by a reduction in income tax and the bonus-malus system. Regarding improvements in average peak hour speed, changes on motorways and in cities prove to have significant influence. An increase in the average peak hour speed leads to an increase in acceptability. In contrast, among the sponsors n comparison to the federal government, the automobile clubs and the environmentalists are more credible, but not to a significant degree.

Concerning the socio-demographic characteristics of the respondents, a higher age and full-time employment increase the probability of choosing the road pricing scheme, whereas owning a car or high car mileage per year reduce it. Furthermore, no significant parameters could be found for household size, gender, public transport subscriptions and income, nor for an interaction term for income and tolls. This latter insight supports the findings of (19) in that income has no influence on the acceptability of road pricing.

The language spoken in the respondent residential location had an influence on the choice probabilities with a lower preference for road pricing in the German- and French-speaking parts of Switzerland in comparison with the base alternative, the Italian-speaking part. The residential area categories have also been coded as dummy variables against the base alternative of living in a city. Despite the findings shown in FIGURE 3, the estimation results indicate no significantly different choice behaviour for respondents living in other residential areas.

TABLE 3 Parameters of the model for the political SP experiment

Variable	Level	Parameter	(t-test)
Constant current system		1.44	(2.40)
Standard deviation for panel term		1.96	(23.22)
Toll [CHF]		-6.19	(-4.71)
Sponsor	Automobile clubs	0.14	(0.73)
	Environmentalist groups	0.12	(0.68)
Type of road pricing	Motorway toll	0.66	(3.19)
	Km-dependent toll	1.10	(5.80)
	Time-dependent toll	0.10	(0.47)
Use of revenues	Bonus-malus system	0.18	(1.08)
	Investment in PuT	0.70	(4.00)
	Reduction in income tax	0.26	(1.85)
Improvement of average peak hour speed [km/h]	On motorways	0.01	(2.66)
	On rural roads	-0.01	(-0.98)
	On urban roads	0.05	(1.74)
Gender	Male	-0.13	(-0.75)
Age		0.02	(2.90)
Language	German	-0.17	(-0.48)
	French	-0.88	(-2.24)
Household size		-0.03	(-0.43)
Household income [CHF/year]		-0.14	(-0.78)
Employment	Full-time employment	0.53	(2.89)
Car availability	Always	-0.34	(-2.00)
Car mileage [1000 km/year]		-0.03	(-3.58)
Public transport subscription	GA holder	0.14	(0.65)
Residential area	Urban agglomeration	0.07	(0.29)
	Smaller agglomerations	0.26	(1.08)
	Rural areas	0.27	(1.13)
Number of observations		5910	
Final log likelihood		-3294	
Adjusted rho square:		0.16	

CONCLUSIONS

The aim of the study reported here was to measure the influence of various design elements on the acceptability of a road pricing scheme. In the SP survey that was the basis for this analysis, respondents were asked to imagine a referendum situation and to decide if the proposed road pricing scheme should be introduced. The results of the survey were analysed to explore the acceptability of different design elements.

As could be foreseen, the proposed cost level proved to be the most important factor. In the survey, a wide range of cost levels was tested, ranging from 75% of the current fuel tax up to 250%. Increasing costs decrease the acceptability of a road pricing scheme. Therefore, the cost level should be well balanced between an effective control of transport behaviour and the acceptability of the scheme. The implied values of travel time savings for motorway travel are consistent with the results typically found in Switzerland.

So far, distance-based motorway tolls and km-dependent tolls for all roads are the preferred pricing types. They are easy to understand and implement. Motorway tolls are already known from foreign

examples and it is intuitive to pay for driving on a better and quicker type of road, whereas the km-dependent toll is an effective measure for reducing the overall amount of car use. However, the list of pricing types tested here is not comprehensive. In particular, combinations of different pricing types, e.g., a time-dependent area pricing, have not been evaluated. Such pricing schemes are very popular among experts because of their effectiveness in reducing congestion, but their public acceptability is rather low. As could be shown in this study, people prefer pricing schemes that they are familiar with and understand. Thus, an increase in acceptability for other pricing schemes can only be achieved through more education about these schemes and their benefits.

Another important issue is the use of the revenues. Many studies have demonstrated that it can be crucial for the successful implementation of a road pricing scheme. The use of the revenues has to be coherent with the design of the road pricing scheme and support its aims. Thus, the most favoured spending option is investment in public transport, which is also a measure to influence transport demand and is perceived by the public as an effective way to reduce congestion. Reductions in income tax and a bonus-malus system that redistributes the revenues back to the Swiss population are other acceptable ways of distributing revenues. In addition, the bonus-malus system gives further incentives to reduce the personal car mileage per year. Only the abolition of existing pricing types such as fuel tax and the motorway vignette were not liked. People are used to them and accept them as necessary.

Another important factor influencing the acceptability of road pricing schemes are the benefits delivered to travellers and society. These benefits are represented here by the improvement of average peak hour speed. Improvements on motorways and urban roads especially increased the acceptability. However, simple and abstract statements like this do not convince people of the benefits of a specific road pricing scheme. In fact, the benefits of the scheme have to be demonstrated in a detailed study that tests scenarios under specific local conditions and explains the implications of road pricing and its flanking measures on route, mode, destination and departure time choices. Thus, people can experience the envisaged reduction in congestion beforehand and are more likely to accept the road pricing scheme.

ACKNOWLEDGMENTS

The work presented in this paper was commissioned by the Swiss Association of Transportation Engineers as part of the research program Mobility Pricing by the Swiss Federal Department of the Environment, Transport, Energy and Communications and the Swiss Federal Roads Authority. We are grateful for the suggestions and help of the steering committee chaired by Paul Widmer. We are grateful to Swiss Railways (SBB) for access to their national survey. The surveys were generated by PTV AG, Karlsruhe and dispatched by ESPAS AG, Zürich. Their contribution was central for the success of this study.

LITERATURE

1. Schweizerischer Bundesrat (2004) Verordnung über eine leistungsabhängige Schwerverkehrsabgabe (Schwerverkehrsabgabeverordnung, SVAV), SR 641.811, Bern

2. Schweizerischer Bundesrat (1996) Verordnung über die Abgabe für die Benützung von Nationalstrassen (Nationalstrassenabgabe-Verordnung, NSAV), SR 741.72, Bern.

3. Transport for London (2003). Central London congestion charging scheme: Three months on, www.tfl.gov.uk/tfl/pdfdocs/congestion_charging/cc-three-month-report.pdf, Transport for London, London, November 2005.

4. Olszewski P. and X. Litian (2005) Modelling the effects of road pricing on traffic in Singapore, *Transportation Research*, **39A** (7-9) 755-772

5. HMSO (2000) Road Pricing: the public viewpoint, in B. Johansson and L-G. Mattsson (eds) *Road Pricing: Theroy Empirical Assessment and Policy*, 159-180, Kluwer, Boston.

6. Schade, J. (2003) European research results on transport pricing acceptability, in J. Schade and B. Schlag (eds.) *Acceptability of Transport Pricing Strategies*, 109-124, Elsevier, Oxford.

7. Vrtic, M., N. Schuessler, A. Erath and K.W. Axhausen (2007) Route, mode and departure time choice behaviour in the presence of mobility pricing, paper to be presented at the 86th Annual Meeting of the Transportation Research Board, Washington DC.

8. Vrtic, M., N. Schuessler, A. Erath, K.W. Axhausen, E. Frejinger J. Stojanovic, M. Bierlaire, R. Rudel and R. Maggi (2006) Einbezug von Reisekosten bei der Modellierung des Mobilitätsverhalten, final report for SVI research programm Mobility Pricing: Projekt B1,on behalf of Eidgenössisches Departement für Umwelt, Verkehr, Energie und Kommunikation and Bundesamt für Strassen, IVT ETH Zurich, ROSO EPF Lausanne and IRE USI Lugano.

9. Ryley, T. and N. Gjersose (2006) Newspaper response to the Edinburgh congestion charging proposals, *Transport Policy*, **13** (1) 66–73.

10. Harsman, B. (2003) Success and failure: Expericences from cities, in J. Schade and B. Schlag (eds) *Acceptability of Transport Pricing Strategies*, 187-202, Elsevier, London.

11. Schade, J. and B. Schlag (2000) Acceptability of Urban Transport Pricing, *VATT Research Report*, **72**, VATT, Helsinki.

12. Link, H. and J.W. Polak (2001) How acceptable are transport pricing measures? Empiciral studies in nine Europeaen Countries, Proceeding of the 29th European Transport Conference, PTRC, London.

13. Jaensirisak, S., M. Wardman and A.D. May (2005). Explaining variations in public acceptability of road pricing schemes, *Journal of Transport Economics and Policy*, **39** (2) 127–154.

14. Armelius, H. and L. Hultkrantz (2006) The politico-economic link between public transport and road pricing: An ex-ante study of the Stockholm road-pricing trial, *Transport Policy*, **13** (2) 162-172.

15. Smith, A. (1776) *The Theory of Moral Sentiments*, edited by D.D. Rapheal and A.L. Macfie, 1976, Claendon Press, Oxford:

16. Jaensiriak, S., A.D. May and M. Wardman (2003) Acceptability of road user charging: the influence of selfish and social perspectives, in J. Schade. and B. Schlag (eds.) *Acceptability of Transport Pricing Strategies*, 235-248, Elsevier, London.

17. Schade, J., B. Schlag, A. Beier and I. Giannouli (1999) Acceptability of marginal cost read pricing, *Deliverable 2c of the AFFORD project*, 4th Transport RTD Programme of the EU, Dresden/Helsinki.

18. Festinger, L. (1957) *A Theory of Cognitive Dissonance*, Stanford University Press, Stanford.

19. Rienstra, S.A., P. Rietveld and E.T. Verhoef (1999) The social support of policy measures in passenger transport: A statistical analysis for the netherlands, *Transportation Research*, **4D** (3) 181-200.

20. Steg, L (2003) Factors influencing the acceptability and effectiveness of transport pricing, in J. Schade and B. Schlag (eds.) *Acceptability of Transport Pricing Strategies*, 187-202, Elsevier, London.

21. Schlag, B. and J. Schade (2000) Public acceptability of traffic demand management in Europe, *Traffic Engineering & Control*, **41** (8) 314-318.

22. Bamberg, S. and D. Rölle (2003) European research results on transport pricing acceptability, acceptabilty of pricing strategies, in Schade J. and B. Schlag (eds) *Acceptability of Transport Pricing Strategies*, 235-248, Elsevier, Oxford.

23. CfiT (2002) Public attitudes to transport in England: The CfiT report 2002, Commission for Integrated Transport, London.

24. Hölzer, O. (2003) European research results on transport pricing acceptability, in J. Schade and B. Schlag (eds) *Acceptability of Transport Pricing Strategies*, 235-248, Elsevier, London.

25. SBB (2005) Kontinuierliche Erhebung Personenverkehr (KEP), Schweizerischen Bundesbahnen, Bern.

26. Hackney, J.K., Z. Oblozinska and K.W. Axhausen (2004) Qualität des Verkehrsangebots: MIV Endbericht, *Arbeitsberichte Verkehrs- und Raumplanung*, **213**, Institut für Verkehrsplanung und Transportsysteme (IVT), ETH Zürich, Zürich.

27. Axhausen, K.W., S. Hess, A. König, G. Abay, J.J. Bates and M. Bierlaire (2006) State of the art estimates of the Swiss value of travel time savings, paper presented at the *86th Annual Meeting of the Transportation Research Board*, Washington, D.C., January 2007.

28. Richmond, J.E.D (2002) *Transport of Delight: The Mythical Conception of Rail Transit in Los Angeles*, University of Akron Press, Akron.

29. McFadden, D. (1974) Conditional logit analysis of qualitative choice behaviour, in P. Zarembka (ed.) *Frontiers in Econometrics*, 105-142, Academic Press, New York.

30. Ben-Akiva, M.E. and S.R. Lerman (1985) *Discrete Choice Analysis*, MIT Press, Cambridge.

31. Bierlaire, M. (2005) An Introduction to BIOGEME (Version 1.3), http://roso.epfl.ch/mbi/biogeme/doc/tutorialv13.pdf, Operations Research Group, EPF Lausanne, Lausanne, Juni 2006.