Modelling acceptability of the intelligent speed adapter

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Abstract

The Intelligent Speed Adapter (ISA) is an example of in-car telematics equipment that is developed to reduce speeding. It can be introduced as a policy instrument to improve speed limit compliance and with that traffic safety. However, previous research indicated that acceptability of this type of instruments is rather limited. Adopting a policy that may increase acceptability before introduction of the instrument is therefore recommended. To formulate such a policy, understanding the factors that influence ISA acceptability is required. To that effect, a causal model that disentangles the direct and indirect effects of predictor variables on ISA acceptability is developed and estimated. The model includes car drivers’ attitudes, opinions and beliefs on the speeding problem, the policy goal and the policy instrument ISA, as well as speed related behaviour and socio-demographic variables. This paper presents the direct and total effects of these variables on ISA acceptability. The results suggest that explaining clearly how ISA can contribute to attaining various personal and societal goals may be a viable policy to increase ISA acceptability.

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1. Introduction

In order to increase traffic safety, the Dutch, and other European governments are considering the introduction of an Intelligent Speed Adapter (ISA). ISA is an in-car electronic driving aid system operating on the car’s speed in response to current speed limit information (Brookhuis & De Waard, 1999; Comte, 2001; Várhelyi & Mäkinen, 2001). This information is received from devices operating from roadsides or from global positioning techniques in combination with route guidance systems. When the car reaches the local speed limit, ISA can either warn the driver or directly limit the car’s speed. In case ISA warns the driver by means of an auditory, visual or a haptic signal, the driver should respond but keeps control over the car’s speed. Otherwise, driver’s control is overruled.

This instrument has great potential to contribute to traffic safety as speeding has a definite, well-known relationship to accident involvement. Salusjärvi (1981) reported an almost linear relationship between change
in number of accidents and change of mean speed, in Finland. Similarly, Joksch (1993) found that the probability of a driver being killed increases with increased speed. He fitted regression models with exponents as high as four, implying that each km/h faster exponentially increases fatality risk. An average reduction of as little as 2 km/h to 5 km/h could lead to a reduction of 10% up to at least 30% in injury accidents (for a more elaborate overview, see Rothengatter, 1993).

However, from the recent debate on strategies for introduction of registration systems with the aim to influence road use and impact of road use (Schade & Schlag, 2003; Van der Laan, 1998), it is clear that acceptability of vehicle instrumentation is not high. Acceptability of pricing instruments, for instance, are very much dependent upon their purpose (Schade, 2003); pricing for long distance driving is judged highly unacceptable (91%) whereas pricing for \( P + R \) is not (8%). Doubts have already been raised about the acceptability of ISA as an influencing instrument (Brookhuis & De Waard, 1996). Results from a questionnaire survey demonstrated that a slight majority of the driving population considered the speed-limit warning mode useful, whereas only 35% of the respondents indicated the speed limiter was useful (Hagen & Fokkema, 1990). The limit mode is probably perceived by drivers as a limitation of their (driving) freedom. This may stimulate them to regain their freedom either by sabotaging the system or by other compensatory behaviour, which may counterbalance the instrument’s positive effects. Some indications for this type of behaviour have been found in an evaluation study on voluntary speed adapters for lorries and buses (Wilbers, 1992). In the test phase, several drivers switched off the speed adapter one or more times. A similar behaviour was reported by Jamson (2006) who found that specifically drivers who would need ISA most, were less likely to use a voluntary ISA system. Hence, successful introduction of ISA as an effective instrument to maintain speed limits is highly dependent on its acceptability. It seems therefore necessary to develop strategies to increase ISA acceptability.

A viable strategy to increase ISA acceptability could be to specify the instruments’ functionality according to car drivers’ preferences. This strategy is probably relatively easy to implement, being based on current preferences and not requiring changes in existing preferences. However, as car drivers prefer the warning mode on all road types outside the build-up area (Van der Heijden, Molin, & Heijer, 1998), this strategy would result in a system that allows them to still violate speed limits and therefore may not be sufficiently effective. An alternative strategy could be to introduce an ISA type that is effective on all road types, i.e., a system that does more than simply warning (Várhelyi & Mäkinen, 2001). However, as at most 50% of the car drivers currently accepts such an instrument (Vlassenroot, De Mol, & Broekaert, 2004), it is not easily introduced. Hence, the successful implementation of this strategy probably requires an “accompanying” policy to influence acceptability of other than warning type of ISA before introduction. To find starting points for developing such a policy, insight into the factors that influence ISA acceptability is required.

The goal of this paper is to explore what kind of variables are (causally) related to ISA acceptability and to what extent. To that effect, a conceptual model for ISA acceptability is developed. The selection of the potential predictor variables is discussed and it is hypothesized how these variables are directly or indirectly related to ISA acceptability. Structural Equation Modelling (SEM) is applied to model these relationships. The direct and total effects of the variables on ISA acceptability are presented and discussed.

2. Towards a structural equation model (SEM) of ISA acceptability

2.1. The selection of variables

The selection of variables to be included in the SEM model was led by the view to regard ISA as a policy instrument that the government may use to improve compliance to speed limits. Based on previous research (e.g. Marchau, 2000) drivers’ opinions, attitudes and beliefs related to various stages in this policy making process are assumed to influence ISA acceptability. These factors are identified in this section as potential factors in the ISA acceptability model and their hypothesized effect on ISA acceptability is discussed.

First it is conjectured that ISA may be adopted as a reaction to awareness, i.e. speeding is a problem. The following indicators are selected to measure the awareness that speeding is a problem: (i) the belief that speeding causes accidents, (ii) feelings with respect to safety in traffic, (iii) opinion on current speed limits. The extent to which the policy goal to improve compliance to speed limits is supported influences ISA acceptability. Thus, the perception of own speed exceeding behaviour was selected additionally.
Next, the car drivers’ beliefs about the selected policy instrument may influence acceptability. It seems plausible to assume that the stronger the belief that ISA is an effective instrument in attaining various societal and personal policy goals, the higher its acceptability. Furthermore, car drivers may vary in their preferences for a warning or a limiting mode on various road types. Finally, it is hypothesized that the stronger one prefers the limiting mode, the more one is willing to accept ISA.

In addition to the described factors, it is assumed that car drivers’ personal characteristics may influence ISA acceptability. Among those are the socio-demographic variables gender, age, education and also specific car use behaviour. For instance, it is expected that males are less willing to accept ISA than females as speeding is more related to typical male (macho) behaviour. With respect to age it is assumed that ISA acceptability increases with age as traffic experience comes with age and therefore also the awareness of the dangers of speeding. Furthermore, it is assumed that frequency of car use may influence ISA acceptability. More experienced car users may like driving more and may therefore reject a limitation of their driving freedom. Moreover, in absolute terms they experience the effect of the instruments more than occasional users. Therefore, it is hypothesized that the more one uses the car, the less one is willing to accept ISA. Finally, ISA acceptability is assumed to decrease with increasing levels of education, higher educated bearing the consequences of their own behaviour and being less inclined to accept an instrument that limits their behaviour.

2.2. The assumed causal order

The selected variables may either directly or indirectly affect ISA acceptability, which implies that they are assumed to influence each other as well. In order to estimate these causal effects, the following causal order among the variables is assumed. First, the socio-demographic variables gender, age, and education are considered to be true exogenous variables, i.e. not influenced by any other variable in the model. Although these variables may be correlated, their relationship is not interpreted in causal terms. The exogenous variables may however influence any other selected variable.

Car use is assumed to come second in the causal rank order. Thus, car use is conjectured to be influenced mainly by the socio-demographic variables, while it may affect any remaining variable in the model. Of all problem awareness indicators, the belief that speeding is causally related to accidents is of primary importance. It is hypothesized that the more one believes this relationship is true, the less safe one feels in uncontrolled traffic. In turn, the less safe one feels in traffic, the more one supports the opinion that current speed limits are already too high; and finally, the opinion that current speed limits are already too high leads to speed limit compliance. Therefore, all the problem awareness indicators may influence the support for the policy goal and the instrument’s opinions. With respect to instrument opinions, it is assumed that the beliefs on the effectiveness of ISA influence the preferences on how the instrument should be specified, that is, the extent to which a limiting functionality is preferred. Finally, all selected variables are assumed to directly or indirectly influence ISA acceptability, positioned at the end of the causal chain. The conjectured causal order is presented in Table 1.

3. Method

3.1. Measurements

Table 1 specifies the questions as formulated in the questionnaire, the extremes of the response scales, and sub-questions. The sub-questions requested respondents to differentiate their responses to different road types, types of traffic participation, and goals. The sub-questions provide detailed measurements and are used to arrive at sorted scales that are assumed to provide more reliable measurements compared to single indicators. Five-point scales have been used as a response format for most questions.

As presented in Table 1, car use is a summed score of different variables. While frequency of use and annually driven kilometres are measured straightforward, the other two variables need some clarification. Percentage car use for commuting was measured by requesting respondents to set the annually driven kilometres at 100% and distribute the percentages over five named activities. To measure the indicator variable number of activities for which the car is primary mode was measured by requesting respondents to indicate which mode
they most often used for the five mentioned activities. The number of times the car was mentioned was summed across the activities. Thus, the variable car use does not only express the amount of car use, but also the dependency on the car as the main mode of transport.

To measure ISA acceptability, the following series of indicator variables were measured. First, respondents were requested to indicate whether they would like to have an ISA if the functionality was specified as preferred. The latter was measured in the preceding question on instrument functionality. Then they were asked whether they still would have ISA if it operates (1) on more roads than preferred, (2) on all roads, (3) only in

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Content question</th>
<th>Extreme of response scale</th>
<th>Specified for</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a Level of education</td>
<td>Highest finished school type</td>
<td>1 elementary school only; 6 university degree</td>
<td></td>
</tr>
<tr>
<td>1b Age</td>
<td>1997 – year of birth</td>
<td>Continuous per year</td>
<td></td>
</tr>
<tr>
<td>1c Gender</td>
<td></td>
<td>0 female/1 male</td>
<td></td>
</tr>
<tr>
<td>2 Car use</td>
<td>Frequency of use</td>
<td>1 never; 5 daily</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Annual driven distance by car,</td>
<td>1 &lt; 5000 km.; 5 &gt; +25000 km</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% car use for commuting,</td>
<td>1 &lt; 20%; 5 80–100%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number of activities for which car is primary mode</td>
<td>0 none; 5 five activities</td>
<td></td>
</tr>
<tr>
<td>3 Cause accidents</td>
<td>The belief that driving too fast is an import cause of accidents</td>
<td>1 no important cause 5 very important cause</td>
<td></td>
</tr>
<tr>
<td>4 Unsafety feelings</td>
<td>Feeling unsafe in traffic if (other) cars drive too fast</td>
<td>1 very unsafe As: pedestrian, cyclist, car driver, car passenger 5 very safe</td>
<td></td>
</tr>
<tr>
<td>5 Limit opinion</td>
<td>Opinion on current speed limits</td>
<td>1 much too low 5 much too high</td>
<td>For each of 7 road types</td>
</tr>
<tr>
<td>6 Speed exceedings</td>
<td>Frequency by which one exceeds current speed limits</td>
<td>1 never 5 very often</td>
<td>For each of 7 road types</td>
</tr>
<tr>
<td>7 Goal support</td>
<td>Importance of policy to reduce speed limit exceedings</td>
<td>1 not important 5 very important</td>
<td>For each of 7 road types</td>
</tr>
<tr>
<td>8 Perceived effectiveness</td>
<td>Belief that ISA can contribute to policy goals</td>
<td>1 does not contribute 5 contributes strongly</td>
<td>For a mix of 5 societial and individual goals</td>
</tr>
<tr>
<td>9 Limiting mode</td>
<td>Preference for ISA functionality</td>
<td>0 warning 1 limiting</td>
<td>For each of 7 road types</td>
</tr>
<tr>
<td>10 Acceptance</td>
<td>Intention to buy ISA if it is for free</td>
<td>1 certainly not 5 certainly</td>
<td>Limiting as preferred</td>
</tr>
<tr>
<td></td>
<td>Wants to posses ISA</td>
<td>1 certainly not 5 certainly</td>
<td>If ISA: limits as preferred</td>
</tr>
<tr>
<td></td>
<td>Support for policy to impose ISA on all cars</td>
<td>1 very bad 5 very good</td>
<td>Limits on all roads, special circumstances</td>
</tr>
<tr>
<td>Road type 1</td>
<td></td>
<td>Roads in living neighborhoods and roads with speed limit 30 km/h</td>
<td></td>
</tr>
<tr>
<td>Road type 2</td>
<td></td>
<td>Roads in built up area, bicyclists on the lane, speed limit 50 km/h</td>
<td></td>
</tr>
<tr>
<td>Road type 3</td>
<td></td>
<td>Roads in built up area, separate bicycle lane, speed limit 70 km/h</td>
<td></td>
</tr>
<tr>
<td>Road type 4</td>
<td></td>
<td>Roads outside built up area, bicyclists on the lane, speed limit 60–80 km/h</td>
<td></td>
</tr>
<tr>
<td>Road type 5</td>
<td></td>
<td>Roads outside built up area, separate bicycle lane, speed limit 80 km/h</td>
<td></td>
</tr>
<tr>
<td>Road type 6</td>
<td></td>
<td>Inter-urban highways, speed limit 100 km/h</td>
<td></td>
</tr>
<tr>
<td>Road type 7</td>
<td></td>
<td>Interstate highways, speed limit 120 km/h</td>
<td></td>
</tr>
</tbody>
</table>

Note: Variables are listed in the assumed causal order. Variables 1a, 1b, 1c are the exogenous variables.
special circumstances, like for example road maintenance works or bad weather. Furthermore, respondents were asked if they would like to have ISA if it was free of charge. Finally, respondents were requested to indicate whether they approved of a policy to impose ISA on all cars if (1) ISA had the functionality they indicated before, (2) ISA operates on all road types, (3) ISA only operates in special circumstances (e.g. bad weather, road works).

3.2. Scale construction

The responses to the sub-questions were assumed to be influenced by a single latent variable. To check this assumption, factor analysis was applied to examine the structure and the dimensionality of the responses. This was followed by a calculation of the Cronbach’s alpha that is an indicator of the reliability of a summed scale. A Cronbach’s alpha larger than .70 is generally considered to have sufficient reliability.

Principal axes factor analysis indeed suggested that a single latent variable underlies the responses to the sub-questions. However, in all four analyses on the road types sub-questions, road type 1, i.e. living neighbourhoods and 30 km zones, appeared to have a low communality. Apparently, people’s opinions with respect to speed maintenance on roads in their direct living environment differ substantially from their opinions on other road types. Hence, road type 1 was excluded from further analysis and the construction of the scales.

The reliability of the remaining indicator variables by the Cronbach’s alpha could not be improved by dropping any of the selected indicator variables. The calculated Cronbach’s alpha’s are presented in Table 2. As the Cronbach’s alpha’s of the intended scales were all above .72, the reliability of these scales was concluded to be reasonable at least. Hence, scale scores were constructed by summing the scores on the constituting indicator variables, equally weighing each variable.

3.3. Procedure

The self-explaining questionnaires were sent out to a random sample drawn from the Dutch telephone book. After correction for companies and incomplete addresses this involved a sample of 1489 households. Multi-person households were requested to decide among themselves who would complete the questionnaire. Within a period of four weeks, 442 road users returned the questionnaire realizing a response rate of 30%, considered to be a normal response rate for mail back questionnaires in the Netherlands. A sub-sample of only 272 car drivers fully completed all the indicator questions on which the analysis presented in this paper is based.

The response group turned out to be representative of the Dutch population with respect to region. Furthermore, categories of city size and type of living neighbourhood were sufficiently represented. The response group was not entirely representative with respect to several other variables. Over-represented were the categories male, older age, higher educated, and car-owner. However, as all background categories are sufficiently represented and we do not have any indications that selective response has occurred within the background categories, we assume that the under-representation did influence the observed correlations and therefore did not affect the model results (see Schmeets & Molin (1991) for empirical support of this assumption).

Table 2
Cronbach’s alpha ($\alpha$) for scale construction

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Scale description</th>
<th>$\alpha$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 car use</td>
<td>The extent to which the car is used</td>
<td>.82</td>
</tr>
<tr>
<td>4 unsafe</td>
<td>Feeling unsafe if (other) cars drive too fast</td>
<td>.77</td>
</tr>
<tr>
<td>5 lim_opin</td>
<td>Opinion on current speed limits</td>
<td>.82</td>
</tr>
<tr>
<td>6 speed_ex</td>
<td>The self reported frequency by which speed limits are exceeded</td>
<td>.89</td>
</tr>
<tr>
<td>7 goal_sup</td>
<td>The importance attached to the policy goal ‘better maintaining speed limits’</td>
<td>.91</td>
</tr>
<tr>
<td>8 effectiv.</td>
<td>Belief that ISA can contribute to attaining goals</td>
<td>.76</td>
</tr>
<tr>
<td>9 lim_mode</td>
<td>Preference for limiting mode</td>
<td>.74</td>
</tr>
<tr>
<td>10 accept</td>
<td>ISA acceptance</td>
<td>.86</td>
</tr>
</tbody>
</table>
3.4. Structural equation modeling (SEM)

SEM is a modelling approach enabling simultaneous estimation of a series of linked regression equations (e.g., Bollen, 1989). SEM contains a family of advanced modelling approaches, among which is path modelling (e.g., Kenny, 1979). A path model is a series of linked regression equations, a path being a causal relationship between two variables. As these regression equations are linked, an independent variable in one equation can be a dependent variable in another equation. Hence, this modelling technique allows to break down the total causal effects into direct and indirect effects. In contrast, ordinary regression analysis is only able to model direct effects: a variable that has only an indirect effect on a dependent variable drops out of the multiple regression model. One then may falsely conclude that the variable had no effect on the dependent variable. SEM retains these indirect effects, which results in potentially more valid conclusions on causal relationships.

A further advantage of SEM is that it provides overall fit measures for the entire model. A traditional measure of overall model fit is to compare the observed correlation matrix with the correlation matrix that can be reconstructed from the estimated model. Significant Chi-square values indicate that the model may be improved, for example, by estimating paths that were assumed to be zero. Modification indices provide indications how much the model fit can be improved if a path that initially was assumed to be zero was freed, that is, a coefficient is estimated for that path. As the Chi-square measure for overall fit is sensitive for the number of cases in the analysis, a range of alternative model fit indicators have been developed. In search of the best fitting, most parsimonious model, assumed paths are tested to significance. To that effect, a $t$-value for each estimated path coefficient is provided. In addition to the path coefficients, SEM estimates how much of the variance of each dependent variable is explained by the variables in the model.

If all variables are included in the model as measured variables, it is assumed, like in ordinary regression analyses, that these are all measured without measurement error. However, this assumption does not hold for the summed scales as indicated by the Cronbach’s alpha. The Cronbach’s provides an indication on the measurement reliability, thus the measurement error of the summed scales can be taken into account by including for each of the summed scales a latent variable that is only measured by the summed scale. Then, the measurement error of the summed scale is fixed by setting it equal to the observed variance of the summed scale times 1 minus the reliability, here represented by Cronbach’s alpha (Jöreskog & Sörbom, 2001). The single variable cause accidents, for which the Cronbach’s alpha cannot be calculated, was assumed to be measured with average reliability ($a = .82$).

4. The estimated model

4.1. Estimation procedure and model fit

An initial model was estimated based on the postulated causal order. This rank order indicates the potential causal relationships between the variables, where variables with a lower rank number are assumed to influence variables with a higher rank number, hence, initially no zero paths are assumed. Furthermore, no reversal causality or feedback loops are assumed, resulting in a recursive model. Thus, in terms of a path model diagram, all possible paths were drawn between variables earlier in the causal order and variables later in the causal order. Furthermore, as no causal effects were assumed among the three socio-demographic variables, correlations were estimated between each pair of those variables, resulting in a saturated model.

The model was estimated with Lisrel 8.5. As some of the variables were considered to have an ordinal level of measurement (level of education, cause accidents), the model was estimated from the asymptotic covariance matrix in addition to the covariance matrix using maximum likelihood method to correct for non normality as suggested by Jöreskog (2001). Jöreskog further suggests to use the Satorra-Bentler scaled Chi-square as a measure for the model fit as this works best in case of relatively small sample sizes like ours.

To arrive at the most parsimonious model, the path coefficients that are not statistically significant at the conventional 95% reliability level are fixed to zero one at a time, starting with the coefficient with the highest $p$-value. As level of education had no statistically significant path to any of the other variables in the model, this variable was dropped from the model. The final model with only all significant paths has a very satisfactory model fit (Satorra-Bentler Scaled Chi-Square = 19.67, 32 degrees of freedom, $P = 0.96$).
4.2. Estimated direct effects

A path model of the estimated model is presented in Fig. 1. For ease of presentation, the indicator variables for the latent variables and the measurement errors are not included in the figure. The estimated standardized direct effects are also presented in table form in Table 3, together with the total effects and the percentage explained variance of all dependent variables. In the following, the direct effects are considered and briefly discussed with respect to the plausibility of the significant relationships. The path coefficients can be interpreted as standardized regression coefficients. Hence, it represents the extent to which an independent variable influences a dependent variable, controlled for all other variables in the model. An indirect effect is calculated by taking the product of the estimated coefficients of the paths that connect two variables.

Car use is directly influenced by both ‘being male’ (.30) and age (−.42): males use the car more than females and car use decreases with age. The belief that speeding is an important cause of accidents is only directly influenced by ‘being male’ (−.46): males less strongly believe that this is the case. Feeling unsafe in traffic if (other) cars drive too fast is only directly influenced by car use (−.28) and more strongly by cause accidents (.52): the more one uses the car, the safer one feels in traffic, while the more one believes that speeding causes accidents, the less one feels safe.

The opinion that current speed limits are too high is directly influenced by age (.30), car use (−.23) and most strongly by cause accidents (.61), with the signs of the relationships in anticipated direction. Remarkable is the finding that limit opinion is not influenced by feeling unsafe: this relationship is explained away by car use and cause accidents. Hence, although the measurement of feeling unsafe relates to cars around you driving faster than current speed limits, this does not affect the opinion on the height of the limit itself.
Speed limit exceeding is directly influenced by car use (.26) and more strongly by limit opinion (−.53). Remarkable is that gender does not have a direct effect, however, it has a positive indirect effect (0.26) suggesting as expected that males more frequently exceed speed limits.

The support for the policy goal to better maintain speed limits is directly influenced by feeling unsafe (.26), speed exceeding (−.16) and most strongly by limit opinion (.52). All three variables refer to the speeding problem acknowledgement, hence, the two socio-demographic variables and car use do not influence policy support directly. However, the latter three variables have a substantial indirect effect (age .29, male .31 and car use .26).

Perceived ISA effectiveness is only directly influenced by policy support (.32). As the explained variance of this variable is relatively low, this suggests that perceived effectiveness is a rather independent concept. The preference for the limiting mode is directly influenced by age (−.27), car use (−.16), goal support (.35) and perceived effectiveness (.37). Hence, limit mode preference increases with decreasing age, decreasing car use, increasing goal support and increasing perceived effectiveness. Remarkable is the result that age has a direct negative effect on limiting mode preference. However, this is completely counterbalanced by positive indirect effects, resulting in a zero total effect. Hence, this suggests that age has no effect on limiting mode. Finally, ISA acceptability is directly influenced by age (.20), cause accidents (.28), perceived effectiveness (.28) and most strongly by preference limiting mode (.50), and all signs are in expected directions. Most striking is the finding that both speed exceeding and goal support do not directly influence ISA acceptability.

Summarising, the signs of all estimated paths were in the expected directions with the exception of the effect of age on preference limiting mode, however, this effect was completely counterbalanced by indirect effects. As the estimated direct paths are found plausible, this implies that also the estimates of the indirect effects are plausible. Thus, it may be concluded that the model is plausible and therefore has at least face validity.

4.3. Estimated total effects on ISA acceptability

Table 3 (last column) presents the total effects of the predictor variables on ISA acceptability. The sign of the effects is considered to evaluate the hypothesis with respect to the effect of the predictor variables on ISA acceptability. Not surprisingly, being male, car use and exceeding speed limits decrease ISA acceptability,
while all other variables increase ISA acceptability. Thus, it may be concluded that all signs are in the hypothesized directions.

The magnitude of the total effects indicates how strong a predictor variable influences ISA acceptability. As the signs of the relationships are just discussed, only the absolute magnitudes are considered. Most remarkable is the finding that the total effect of speed exceedings is relatively low. This relationship is largely explained by the opinion and belief variables. As these variables refer to attitudes while speed exceeding refers to behaviour, attitudes related factors are apparently more basic factors in explaining ISA acceptability than behaviour related variables. Furthermore, feeling unsafe has a relatively low impact, its effect largely explained as discussed before, and also the effect of car use is not that large (probably also because it relates to behaviour as just argued). Age, being male, limit opinion and policy support have a total effect between .20 and .33, which can be considered substantial. However, cause accidents, limiting mode and perceived effectiveness distinctively have the largest total effect on ISA acceptability (range from .44 to .50).

The belief that speeding causes accidents and the belief that ISA can contribute to attaining goals (perceived effectiveness) offers possibilities to influence directly in accompanying policies to the introduction of ISA, for example, by a mass media campaign, while the preference for the limiting mode is much harder to influence directly. Therefore the two belief variables are closer examined. Fig. 2 presents the percentage of the respondents who believed that ISA could contribute in attaining each of five presented goals. The figure shows that maybe with the exception of reduced chance of speed tickets, the belief that ISA can contribute to the selected goals is not very high. Hence, there is a potential to increase the awareness that ISA can contribute to attain goals. This potential is smaller for cause accidents, as already 73.8% of the respondents believe that speeding is an important cause of accidents. Thus, probably the largest potential to influence ISA acceptability is to increase the belief that ISA can contribute to achieve specific goals.

5. Conclusion and discussion

A path model of ISA acceptability was developed and estimated by applying structural equation modelling. The goal of this model was to estimate the direct and indirect effects on ISA acceptability of a large number of predictor variables including car drivers’ beliefs, opinions, attitudes and behaviour with respect to the speeding problem awareness, the formulated policy goal and the choice of ISA as the policy instrument, together with some socio-demographic characteristics. This approach is new in this field, much more common are Multiple Regression Models (Schade & Schlag, 2003) that are more straightforward but less sophisticated. The estimated model indicated that the assumed causal structure was plausible, and the relationships between the predictor variables and ISA acceptability were in the hypothesized directions, which gave confidence to apply the model for identifying promising strategies to influence ISA acceptability. On the whole, Schade (2003) came to similar conclusions for strategies towards influencing acceptability of road pricing instruments.

The present model indicated that the following three variables had the largest total effect on ISA acceptability: (1) the belief that driving too fast is a major cause of accidents, (2) the belief that ISA can contribute to attain various personal and societal goals, (3) the extent to which one prefers an ever limiting ISA. It was argued that especially the first two variables have possibilities to be influenced, for example, by organizing a
mass communication campaign or large demonstrations in advance of ISA introduction. More specifically, these events should focus more on explaining ISA’s contribution to attaining goals than on stressing that speeding causes accidents for the following reasons. Firstly, perceived effectiveness has a larger direct effect, hence, its outcome is more secure. Secondly, part of the indirect effect of cause accidents is intermediated by perceived effectiveness, hence, if both variables are of influence, the indirect effect of cause accidents may be less. Thirdly, the awareness that driving too fast causes accidents is already high, while the belief that ISA can contribute to various goals is much lower. Thus, increasing the awareness of ISA contribution has the largest ‘growth potential’ to increase ISA acceptability.

The empirical basis of the causal relationships is still somewhat limited, as usual in this field (see also, Schade, 2003). The associations are based on correlations between variables that are all measured at the same time without any control or systematic variation of the independent variables. Nevertheless, the outcomes seem plausible, and, since ISA is likely to finally break through into society because of its potential effects, the present indications are useful.

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References


