# Road pricing and road safety

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INSTITUTE FOR
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Possible effects on road safety of 23 variants of road pricing

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# Summary

The Nouwen Committee (National Platform Paying Differently for Mobility) advised the Cabinet in 2005 about the introduction of a system of road pricing. Part of this advice consisted of a calculation of the expected road safety effects of such a system. In a letter to the Minister of Transport, SWOV advised improving these estimates, which resulted in the Joint Fact Finding (JFF) working party inviting SWOV making these estimates using the available data and results. This report contains the results of SWOV's estimated road safety effects of road pricing.

The JFF working party made calculations for 23 road pricing variants. These variants differ in four parameters: the extent of the differentiation (€3.3, 4.9 or 6.8 billion); cost neutrality (at the macro or mesa level i.e. distinguishing between car, van, and lorry; time/place (no differentiation, +11ct/km in the rush hours, or doubling of the differentiating to +5.4 ct/km); and pollution features (not differentiated, by fuel sort, by pollution tax, or the current subdivision).

SWOV has attempted to determine the effects of these variables on categories with very different crash rates. These categories are subdivided into 'human', 'vehicle', and 'road'. For example, the crash rate of young novice motorists is considerably higher than that of experienced ones, and the crash rate of motorcyclists is considerably higher than that of motorists. Unfortunately the available data was not sufficient to make the intended subdivisions for many of the relevant road user groups. The reason for this is that the working party used data that was relevant for accessibility and pollution, and these apparently differ substantially from those important for road safety.

For the category 'human' it was possible to determine the average number of kilometres travelled by car. This is relevant because travelling a larger number of kilometres generally results in a lower crash rate (per kilometre). The effect of road pricing is that each car will be driven 7-17% less. The quantitative road safety effect this will have cannot yet be calculated. For the category 'vehicle' the (average) seat occupancy (of driver and passengers) appeared to be a relevant quantity for the calculations. We assume here that the risk of injury or being killed per kilometre is proportional to the number of occupants. Road pricing thus leads to a 0-3% more unsafe traffic per vehicle kilometre because the number of occupants per car will increase. For the category 'road' we made a subdivision of the expected traffic volumes on three road types: main roads, rural roads, and urban roads. On all these road types the traffic volume will decrease by 4-16% for all 23 road pricing variants. This is striking because we expected that road pricing of the main road network, which mainly consists of the category 'motorways', would cause a traffic shift to the secondary roads consisting of the categories 'rural' and 'urban' which have a higher crash rate. The smaller traffic volume leads to fewer crashes and casualties.
The study concludes that there is insufficient data available to make a sound estimate of the road safety effects of road pricing. Everything that is known indicates that road pricing will result in a possibly substantial road safety

improvement of up to 13% fewer road deaths because the number of kilometres travelled on all road types will decrease considerably.

To make better estimates we recommend carrying out further studies of the following subjects:

- a possible shift of cars to motorcycles;
- moped riders, light-moped riders, cyclists;
- the secondary road network in greater detail;
- the young/the elderly;
- behavioural effects such as speeding, overtaking, and headway distances.

We finally recommend using 'safety' explicitly as a variable in a number of variants, for example to charge a higher price for risky behaviour, risky vehicles, or risky roads.

# Contents

# 1. Introduction

## 1.1. Background

In 2005, the Nouwen Committee (National Platform Paying Differently for Mobility) advised the Cabinet about the introduction of a system of road pricing. In a letter to the Minister of Transport, SWOV advised making better estimates than the ones then used (see *Appendix 2*). Given the circumstances, this was probably the best possible estimate at the time. In a meeting on 6th September of the ministry and SWOV we were invited to make an initial rough estimate of the road safety effects of the variants that had been determined by the working party 'Pricing' of 'Joint Fact Finding' (JFF) project that was part of the Paying Differently for Mobility project. This report contains this estimate.

SWOV used the results of the working party as a basis for her estimates. These results became available in late October 2006. We used the available time to adapt the results to the methods which SWOV generally uses to make estimates of road safety effects. More in particular, we used the current SWOV project Outlooks and the results of an analysis of the decreasing number of road deaths in 2004/2005 (Stipdonk et al., 2006). However, there was insufficient time to further study the effects of road pricing by means of a literature study, specialized data collection, or additional simulations.

## 1.2. Purpose

The goal was to estimate the road safety effects of 23 variants of road pricing and to make recommendations for improving these estimates and those variants in which road safety is the main issue.

## 1.3. Reading guide

In *Chapter 2* those aspects of the traffic system that are important for making estimates are described and grouped according to the categories 'human', 'vehicle', and 'road'. This process views road safety as the product of exposure, i.e. distance travelled, and risk of a fatal crash. The results of these estimates, grouped in the same way, are presented in *Chapter 3*. The most important conclusions are given in *Chapter 4*. Recommendations for further research to improve the estimates and to further study the variants in which road safety is the main issue are to be found in *Chapter 5*.

# 2. Method

## 2.1. Exposure and crash rates

In international road safety research, and thus also at SWOV, road safety is commonly regarded as the product of exposure and crash rate. Therefore this report uses the formula:

number of road deaths = motor vehicle kilometres travelled x deaths per motor vehicle kilometre.

If the total distance travelled and an average crash rate are used, the estimate will be very rough and uncertain. It is better to subdivide or disaggregate the categories. This study attempts to subdivide into groups with clearly different crash rates, in as far as the data on kilometres travelled provided by the Joint Fact Finding project make this possible.

Road pricing can also influence the crash rates themselves. Road authorities can alter the layout of their roads, manufacturers can adapt their vehicles, and people can change their behaviour. In this study these factors have not been taken into account for the categories "vehicle' and 'road'. For the category 'human', behaviour can change at the strategical, tactical, or operational level. Strategic behaviour means, for example, that people travel at different times of day, with other vehicle types, more often or less often, or choose other routes. Our estimates allow for this by disaggregating the distance travelled by various crash rate groups. Tactical behaviour, for example, involves the speed choice, headway distance, or overtaking. This is all relevant for road safety and can possibly be influenced by road pricing. However, at present we do not know how or the extent to which this plays a role and we therefore have not included it in our estimates. It is uncertain whether operational/automatic behaviour such as steering, accelerating, or braking is influenced by road pricing. That is why we have not included this in our estimates either.

## 2.2. Category 'human'

As mentioned earlier, in this category we only analysed changed strategic behaviour. To a large extent this concerns those effects that can be found under 'vehicle' and 'road' via choice of another vehicle, other routes, etc. Here subdivisions by age, experience, and competence (e.g. alcohol use) are important. However, such subdivisions were not possible with the given model results. We attempted to make an estimate for one aspect: the driver's experience. The graph below shows the importance of experience for road safety.

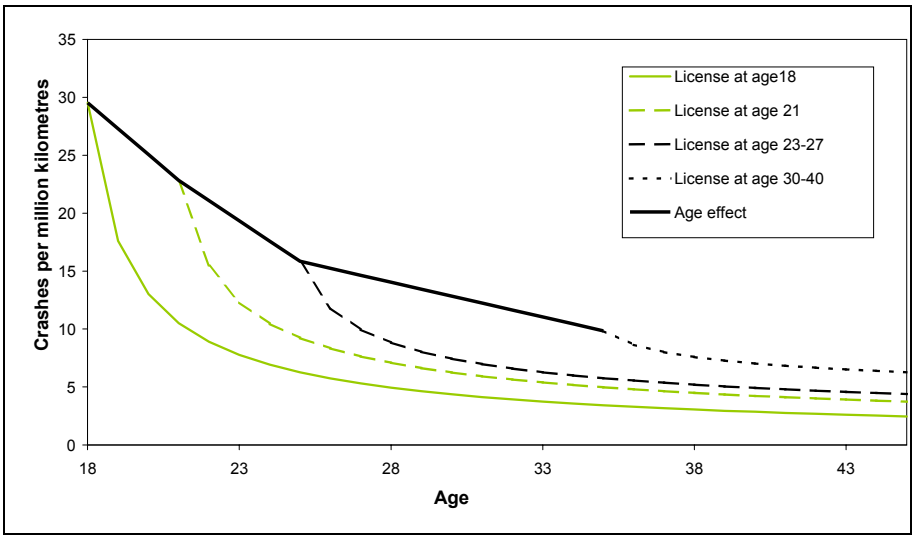


Figure 2.1. *Decrease in crash rate for drivers who began driving at 18 and at later ages (Source: PROV data 1990-2001).*

Young, novice motorists have an extremely high death rate. If road pricing were to result in more young motorists, this could have a considerable negative road safety effect.

## 2.3. Category 'vehicle'

The crash rates for the various vehicle types are very different. The JFF results, however, have not been grouped in the way that is the most relevant for road safety; the crash rates for motorcycles, mopeds, and light-mopeds are considerably higher than those for cars and bicycles. Motorcycles, however, have not been modelled, although their death rate is approximately 20 times higher than for cars. The uncertainty lies in the kilometres travelled by motorcycles which amounts to about one-hundredth of that for cars. A shift of 1% car kilometres to motorcycle kilometres would mean a doubling of the motorcycle kilometres, and possibly 10% more road deaths.

This study has modelled one category, called 'slow traffic', which consists of mopeds, light-mopeds, bicycles, and pedestrians who each have different crash rates. . We therefore used one ratio for motor vehicle kilometres, which includes all deaths, including those among 'slow traffic' (see *Section 3.3*).

Another relevant element is seat occupancy, particularly of cars. This is not directly important for mobility and pollution, at least it does not influence less or more kilometres being travelled, for which this is the relevant quantity. In road safety, vehicle occupation has an influence on both the crash rate and the death rate. For example, young motorists are known to allow themselves to be goaded by contemporaries, known as peer pressure, which increases their crash rate. On the other hand, there are indications that the slightly older men actually drive more safely if they have passengers. This is a subject for further research. This study assumes that the crash rate remains unaltered. Furthermore, we have assumed that the death rate is equal for all car occupants. This means that the number of car occupants killed is proportional to the seat occupancy.

## 2.4. **Category 'road'**

In the SWOV report *Outlook for road traffic* (Janssen, to be published) he made estimates for crash rates in 2020, disaggregated by the usual urban (30, 50, and 70 km/h) and rural (60, 80, and 100/120 km/h) speed limits. These estimates were obtained for each road type and thus for each speed limit by disaggregating crashes only involving slow traffic, involving slow traffic and 'fast' traffic (i.e. all other transport modes), and fast traffic only. The past developments have been fitted with an exponential power, i.e. it was assumed that in terms of percentage, the annual decrease in crash rate is always the same. These exponential functions were then aggregated (summed) to calculate a crash rate per road type.
The JFF results only subdivide by 'main road', 'rural', and 'urban'. Further consultation showed that the 'main road' category probably contained a limited proportion of what SWOV categorizes as '80 km/h' roads. That is why the 'rural' category contains fewer roads than SWOV categorized as 60 and 80 km/h roads. It became ultimately possible to satisfactorily recalculate the rates according to the JFF results; this will be explained in a subsequent account.

# 3. Results

In this chapter the results of the calculations are presented. They refer to the situation in 2000, a calculated situation for 2020 without road pricing, and for 23 variants of road pricing in that year. These variants are described in *Appendix 1*.

## 3.1. Category 'human'

*Table 3.1* lists the average numbers of kilometres travelled per vehicle.

| | Total number of kilometres travelled per year | Car ownership | Average number of kms per car | Index |
|---|---|---|---|---|
| 2000 | 121,248,000,000 | 6,480,000 | 18,711 | |
| 2020 without pricing = reference | 163,354,585,616 | 8,600,000 | 18,994 | 1.00 |
| Variant 1 | 150,910,771,862 | 8,679,844 | 17,386 | 0.92 |
| Variant 2 | 150,274,998,461 | 8,699,309 | 17,274 | 0.91 |
| Variant 3 | 156,955,563,989 | 8,869,680 | 17,695 | 0.93 |
| Variant 4 | 149,664,489,090 | 8,679,844 | 17,242 | 0.91 |
| Variant 5 | 150,629,235,532 | 8,679,844 | 17,353 | 0.91 |
| Variant 6 | 148,843,943,226 | 8,639,699 | 17,227 | 0.91 |
| Variant 7 | 148,315,310,221 | 8,664,845 | 17,116 | 0.90 |
| Variant 8 | 153,651,228,699 | 8,771,066 | 17,517 | 0.92 |
| Variant 9 | 149,491,217,090 | 8,692,849 | 17,197 | 0.91 |
| Variant 10 | 147,667,783,016 | 8,639,699 | 17,091 | 0.90 |
| Variant 11 | 148,465,802,241 | 8,639,699 | 17,184 | 0.90 |
| Variant 12 | 142,300,805,398 | 8,780,891 | 16,205 | 0.85 |
| Variant 13 | 141,818,816,522 | 8,796,534 | 16,122 | 0.85 |
| Variant 14 | 146,165,501,763 | 8,950,628 | 16,330 | 0.86 |
| Variant 15 | 141,480,906,901 | 8,780,891 | 16,112 | 0.85 |
| Variant 16 | 141,873,299,281 | 8,780,891 | 16,157 | 0.85 |
| Variant 17 | 138,610,165,158 | 8,695,749 | 15,939 | 0.84 |
| Variant 18 | 138,342,671,942 | 8,721,034 | 15,863 | 0.84 |
| Variant 19 | 142,417,225,710 | 8,847,359 | 16,097 | 0.85 |
| Variant 20 | 139,529,797,513 | 8,724,659 | 15,992 | 0.84 |
| Variant 21 | 137,829,175,798 | 8,695,749 | 15,850 | 0.83 |
| Variant 22 | 138,238,068,939 | 8,695,749 | 15,897 | 0.84 |
| Variant 23 | 140,663,325,681 | 8,623,535 | 16,311 | 0.86 |

Table 3.1. *Model results for the total annual number of kilometres driven, total car ownership, and average annual number of kilometres driven in 2020 without road pricing (reference) and for 23 road pricing variants.*

The table shows that, according to the SWOV calculations, road pricing causes the average annual distance to drop with 8-17%. This is the consequence of an increase in the total number of vehicles and a decrease in the distance travelled; after all owning a car becomes cheaper and driving becomes more expensive. That is why it is conceivable that the proportion of young and/or inexperienced motorists will increase. The SWOV fact sheet entitled *Young novice drivers* mentions that in 2003 a young motorist was involved in 22% of all serious car crashes, and in *Section 2.1* we have already indicated that this is because their crash rate is so high. An increase in the share of kilometres driven by young or inexperienced motorists will result in an important worsening of road safety. Given the many uncertainties, an estimate of this effect has not yet been made.

## 3.2. Category 'vehicle'

| | Occupants per car | Increase compared with reference |
|---|---|---|
| 2000 | 1.37 | |
| 2020 without pricing = reference | 1.30 | |
| Variant 1 | 1.31 | 1.0% |
| Variant 2 | 1.31 | 1.0% |
| Variant 3 | 1.30 | 0.1% |
| Variant 4 | 1.32 | 1.4% |
| Variant 5 | 1.32 | 1.1% |
| Variant 6 | 1.32 | 1.3% |
| Variant 7 | 1.32 | 1.3% |
| Variant 8 | 1.31 | 0.6% |
| Variant 9 | 1.32 | 1.2% |
| Variant 10 | 1.32 | 1.7% |
| Variant 11 | 1.32 | 1.4% |
| Variant 12 | 1.33 | 2.1% |
| Variant 13 | 1.33 | 2.2% |
| Variant 14 | 1.32 | 1.3% |
| Variant 15 | 1.33 | 2.4% |
| Variant 16 | 1.33 | 2.3% |
| Variant 17 | 1.34 | 2.9% |
| Variant 18 | 1.34 | 2.9% |
| Variant 19 | 1.33 | 2.0% |
| Variant 20 | 1.34 | 2.7% |
| Variant 21 | 1.34 | 3.3% |
| Variant 22 | 1.34 | 3.1% |
| Variant 23 | 1.33 | 2.6% |

Table 3.2. *The average number of car occupants in 2020 without road pricing (reference) and for 23 road pricing variants.*

JFF calculations show that it is expected that the seat occupancy will decline to 1.30 in the reference year 2020. This has been discounted in the estimated crash rate data. The table shows that road pricing will increase the seat occupancy; after all it is better to travel with more people in a car because of the increased marginal kilometre price. According to the assumptions in *Section 2.3* however, the number of road deaths among car occupants will increase with a similar percentage. Although the death rate has been defined as per motor vehicle kilometre, this, of course, does not mean that all road deaths are motor vehicle occupants. The disaggregation by slow traffic, slow + fast traffic, and fast traffic make it possible to correct for this. Especially on urban roads many casualties are slow traffic; approximately two-thirds in 2000. Their proportion on rural roads in 2000 was about one-third, and will be considerably lower in 2020. On main roads practically all deaths are motor vehicle occupants. This correction leads to the increase in seat occupancy being responsible for about two-thirds of the number of road deaths in 2020. For example, variant 21 shows a substantial effect of 2.2%. In *Table 3.3* in the next section, this correction has been rounded off to whole percentages.

## 3.3. **Category 'road'**

| | | Motor vehicle kilometres in billions and numbers of road deaths | | | | Deaths comp. to reference | | Occupancy | After correction |
|---|---|---|---|---|---|---|---|---|---|
| | | Motorway | Rural | Urban | Total | Number | % | | |
| 2000 | billion kms | 50 | 45 | 26 | 121 | | | | |
| | deaths | 148 | 611 | 398 | 1,157 | | | | |
| 2020 without road pricing = reference | billion kms | 73 | 56 | 34 | 163 | | | | |
| | deaths | 144 | 212 | 194 | 550 | - | - | - | - |
| Variant 1 | billion kms | 68 | 52 | 31 | 151 | | | | |
| | deaths | 134 | 196 | 177 | 507 | -42 | -8% | 1.0% | -7% |
| Variant 2 | billion kms | 67 | 52 | 31 | 150 | | | | |
| | deaths | 133 | 195 | 176 | 505 | -44 | -8% | 1.0% | -7% |
| Variant 3 | billion kms | 70 | 54 | 33 | 157 | | | | |
| | deaths | 138 | 204 | 186 | 528 | -22 | -4% | 0.1% | -4% |
| Variant 4 | billion kms | 66 | 52 | 31 | 150 | | | | |
| | deaths | 131 | 196 | 176 | 504 | -46 | -8% | 1.4% | -7% |
| Variant 5 | billion kms | 67 | 52 | 31 | 151 | | | | |
| | deaths | 133 | 196 | 177 | 506 | -43 | -8% | 1.1% | -7% |
| Variant 6 | billion kms | 67 | 51 | 31 | 149 | | | | |
| | deaths | 132 | 193 | 174 | 500 | -49 | -9% | 1.3% | -8% |
| Variant 7 | billion kms | 67 | 51 | 31 | 148 | | | | |
| | deaths | 131 | 193 | 174 | 498 | -51 | -9% | 1.3% | -8% |
| Variant 8 | billion kms | 69 | 53 | 32 | 154 | | | | |
| | deaths | 136 | 200 | 181 | 516 | -33 | -6% | 0.6% | -6% |
| Variant 9 | billion kms | 67 | 52 | 31 | 149 | | | | |
| | deaths | 132 | 194 | 175 | 502 | -47 | -8% | 1.2% | -8% |

| | | Motor vehicle kilometres in billions and numbers of road deaths | | | | Deaths comp. to reference | | Occupancy | After correction |
|---|---|---|---|---|---|---|---|---|---|
| | | Motorway | Rural | Urban | Total | Number | % | | |
| Variant 10 | billion kms | 66 | 51 | 31 | 148 | | | | |
| | deaths | 130 | 193 | 174 | 497 | -53 | -10% | 1.7% | -8% |
| Variant 11 | billion kms | 66 | 51 | 31 | 148 | | | | |
| | deaths | 131 | 193 | 174 | 499 | -50 | -9% | 1.4% | -8% |
| Variant 12 | billion kms | 64 | 49 | 29 | 142 | | | | |
| | deaths | 126 | 185 | 166 | 477 | -71 | -13% | 2.1% | -11% |
| Variant 13 | billion kms | 64 | 49 | 29 | 142 | | | | |
| | deaths | 126 | 185 | 165 | 475 | -72 | -13% | 2.2% | -12% |
| Variant 14 | billion kms | 65 | 51 | 30 | 146 | | | | |
| | deaths | 129 | 191 | 171 | 491 | -58 | -11% | 1.3% | -10% |
| Variant 15 | billion kms | 63 | 49 | 29 | 141 | | | | |
| | deaths | 125 | 185 | 165 | 475 | -74 | -13% | 2.4% | -12% |
| Variant 16 | billion kms | 63 | 49 | 29 | 142 | | | | |
| | deaths | 126 | 185 | 165 | 476 | -72 | -13% | 2.3% | -12% |
| Variant 17 | billion kms | 62 | 48 | 28 | 139 | | | | |
| | deaths | 123 | 180 | 160 | 464 | -83 | -15% | 2.9% | -13% |
| Variant 18 | billion kms | 62 | 48 | 28 | 138 | | | | |
| | deaths | 123 | 180 | 160 | 463 | -84 | -15% | 2.9% | -13% |
| Variant 19 | billion kms | 64 | 49 | 29 | 142 | | | | |
| | deaths | 126 | 185 | 166 | 478 | -70 | -13% | 2.0% | -11% |
| Variant 20 | billion kms | 63 | 48 | 29 | 140 | | | | |
| | deaths | 124 | 181 | 162 | 467 | -80 | -15% | 2.7% | -13% |
| Variant 21 | billion kms | 62 | 48 | 28 | 138 | | | | |
| | deaths | 122 | 180 | 160 | 462 | -86 | -16% | 3.3% | -13% |
| Variant 22 | billion kms | 62 | 48 | 28 | 138 | | | | |
| | deaths | 123 | 180 | 160 | 463 | -84 | -15% | 3.1% | -13% |
| Variant 23 | billion kms | 63 | 49 | 29 | 141 | | | | |
| | deaths | 125 | 183 | 163 | 471 | -76 | -14% | 2.6% | -12% |

Table 3.3. *Overview of the estimated road pricing effect on the number of road deaths. Differences have occurred in the numbers because of rounding up/down.*

*Table 3.3* shows how the distances travelled in the JFF calculations change when multiplied by the SWOV estimated death rates. It is striking that apparently hardly any traffic shifts from the main road network to the secondary network. Such a shift would have an important road safety effect: every billion motor vehicle kilometres that shifts to the secondary network causes an increase of approximately two road deaths. At present this effect is anyway larger than it will be in 2020, because the difference between the death rates on main and secondary roads is larger now than in will be in 2020.

By the substantial decrease in kilometres travelled on all three road types, all variants of road pricing lead to a large road safety improvement of 4-16%, measured in the number of road deaths.

The variants differ in four parameters: the size of the sum (€ 3.3, 4.9 or 6.8 billion); cost neutrality (at the macro or mesa level, i.e. distinguishing between car, van, and lorry; time/place (no differentiation, + 11ct/km in the rush hours, or doubling of the differentiation to + 5.4 ct/km); and pollution features (no differentiation, by fuel sort, by pollution tax, or the current division). By now comparing the variants that differ by one feature only we can see the extent of their road safety effect. Variants 1 and 12 only differ in the amount of differentiation, and this also applies to variants 2 and 13, 3 and 14, etc. The road safety effect is the percentage fewer deaths in the '%' column. This is an arbitrary choice. However, the 'after correction' column hardly leads to other conclusions.

More differentiation is good for road safety. On average, the situation is 6% more favourable for a € 6.8 billion differentiation than for one of € 3.3 billion. Variant 23 is an intermediate variant at a € 4.9 billion is differentiation. When compared with variant 20 which only differs in the size of differentiation (€ 6.8 billion) its results are hardly any less (1%).

Keeping the costs neutral per vehicle type (at the meso level: by car, van, or lorry) is 1 to 2% more favourable than neutrality at the macro level. The effect is strengthened by a greater differentiation.

Differentiating by time and place has hardly any road safety effects, which is of course because it has little to do with the total distance travelled or its subdivision among the groups of roads. Only at the meso level does the + 11 ct/km variant benefit an extra 1% safety that, however, is probably nullified by a higher seat occupancy.

A distinction between pollution features has no safety effect, except the variant in it is differentiated by pollution tax. This results in a 3% road safety decrease because more kilometres are travelled.

# 4. Conclusions

In SWOV's letter of 8th August 2005 to the Minister of Transport (*Appendix 2*) a number of possibilities were given to improve the estimates of road pricing effects on road safety. Unfortunately it has not been possible to carry out the majority of the proposed improvements making use of the present data and results. What is relevant for mobility and pollution is only partly relevant for road safety. The reverse is also the case: much of what is relevant for road safety apparently is not relevant for mobility and pollution. This is the case for categories that sometimes have a considerably higher death rate, such as powered two-wheelers, young novice motorists, or 60 km/h roads. A shift to these groups can have a substantial negative road safety effect that will probably neutralize the positive effects of reducing the distance travelled. What is more, there has not yet been a literature study of effects of road pricing on behaviour at the tactical or operational level. The minimal shift from main roads to secondary roads is also striking. It is possible that specific measures to prevent this have been included in the variants. These limitations mean that any conclusions are not firm, but rather point in a particular direction.

With the above reservations, SWOV has calculated that road pricing such as in the analysed variants can lead to a substantial road safety improvement of up to 13% fewer road deaths. This effect is practically all due to a decline in the total distance travelled. Here it is particularly the amount made available for the differentiation that is important; differentiation by time and place or pollution features have hardly any influence. Differentiating by pollution features can even have negative road safety effects. Apart from that, that differentiation above € 5 billion seems to have little extra benefit.

Possible negative effects of road pricing are that the proportion of inexperienced motorists will rise and seat occupancy will increase. This last will be accompanied by a decrease in the number of motor vehicle kilometres which is positive for road safety.

# 5. Recommendations

## 5.1. Further study of effects of current variants

For a number of vehicle types we know that they have a considerably higher death rate than the alternatives do. This applies to motorcycles versus cars, and mopeds/light-mopeds versus bicycles or public transport. It is possible that this has been taken into account in the variants as a precondition, whereby it is implausible that shifts between vehicle types will occur. It may also be possible is that these types of shift are not relevant for mobility and pollution. In that case they still need to be included for road safety studies.

Something similar applies to the distribution of traffic in the road network. The National Model System (LMS) only models a limited part of the road network; particularly secondary roads are not, or only roughly, included. The data on distances travelled on urban roads in 2000 differs quite substantially from the data SWOV uses. For 2020 however, the situation is comparable. The Platform Paying Differently for Mobility apparently expects a sharp increase in urban kilometres travelled for the coming years.

The death rate of young and/or novice drivers is considerably higher than that of experienced motorists. It would therefore be a good idea to have a better insight in the distances travelled by the young and/or novice drivers and its influence on road pricing.

Different behaviour probably is related to different journey purposes and thus to different crash rates. The journey purpose is important for mobility and road pricing and probably also for road safety. Further research on this topic will soon be carried out in Hasselt, Belgium for a PhD dissertation.

Other behavioural effects of road pricing such as driving speed, overtaking, and headway distance have not been studied. In the short term this can be accomplished by a literature study or driving simulator study. We recommend intensive monitoring after an important measure becomes obligatory because behaviour in practice can surprise us.

## 5.2. Variants for road safety

The safety parameter was not included in the current variants studied. We do however know that a financial stimulus can make people drive safer. This can be done by vehicle choice, route choice, and also by driving behaviour. Road pricing can probably be profitable with such a variant, and we also recommend including such safety variants in subsequent studies.

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# Appendix 1 Calculation of road pricing variants

An internal memorandum for the JFF group gives a detailed description of the variants to be calculated. Below, we discuss a selection from this memorandum because a lot of information about the variants is not relevant for road safety calculations. This is because differences between variants often have no direct road safety effect. In some cases there could be a relation but the necessary data is not available or does not result from calculations by the organizations. The most important known indirect effect is the number of kilometres travelled, subdivided by three road types: main road, rural road, and urban road; as you will find in *Table 3.3.*

The 23 calculated variants differ in the following ways:

First of all there are three different amounts which must be differentiated. These are based on the present Road Tax revenue and the revenues from car and motorcycle taxes (CMT). If this last is differentiated for 25% it will amount to € 3.3 billion. If it is differentiated for 100% and this is also done for the current national surcharges for lorries on motorways and provincial road tax surcharges, it will amount to € 6.8 billion. Only for variant 23 the calculation is made with € 4.9 billion, which amount consists of the lorry surcharge, the road tax, and the CMT.

Furthermore it has been agreed upon that road pricing must not present the road user with extra costs. This is achieved in two ways: at the macro level and at the mesa level, distinguished by vehicle type: car, van, lorry.

The third possibility is to differentiate by time and place. When and where it is busy, the road user pays extra. Precisely which times and places these are has not been indicated by the JFF, but is of course known. SWOV has not included this in its calculations because crash rate data per hour of the day are either not reliable enough or unknown. The indicator 'place' has been used in the calculations, subdivided in three road categories. The basic tariffs are 2.7 cent and 5.6 cent respectively; a factor 2 means 5.4 cent or 11.2 cent; which is less than the +11 cent variants of 13.7 cent and 16.6 cent respectively per kilometre driven.

Finally, the differentiation can be made by pollution features. To this end, distinction can be made according to fuels type (petrol, diesel, LPG) or the current pollution tax (subdivided by Euro class, vehicle type: car, van, lorry.

| Differentiation | Cost neutrality | Time/place | Pollution features | No. |
|---|---|---|---|---|
| € 3.3 bln. | Macro | None | None | 1 |
| | | | By fuel type | 2 |
| | | | By pollution tax | 3 |
| | | + 11 cent | None | 4 |
| | | Factor 2 | None | 5 |
| | Meso | None | None | 6 |
| | | | By fuel type | 7 |
| | | | By pollution tax | 8 |
| | | | Current subdivision | 9 |
| | | + 11 cent | None | 10 |
| | | Factor 2 | None | 11 |
| € 6.8 bln. | Macro | None | None | 12 |
| | | | By fuel type | 13 |
| | | | By pollution tax | 14 |
| | | + 11 cent | None | 15 |
| | | Factor 2 | None | 16 |
| | Meso | None | None | 17 |
| | | | By fuel type | 18 |
| | | | By pollution tax | 19 |
| | | | Current subdivision | 20 |
| | | + 11 cent | None | 21 |
| | | Factor 2 | None | 22 |

Table 1. *Structure of various road pricing variants.*

| | |
|---|---|
| Amount | € 4.9 billion |
| Cost neutrality | Meso level (with distinction by vehicle type: car, van, lorry) |
| Time and place | No differentiation |
| Pollution differentiation | Differentiation based on current differentiation in Road Tax and CMT (by weight and by price) |

Table 2. *Structure of variant 23.*

# Appendix 2 SWOV letter concerning ‘Paying Differently for Mobility’ of 8th August 2005

Dear Ms Peijs,

The 'Paying Differently for Mobility' Platform, known as the Nouwen Committee, has drawn up an advice for you and the Minister of Finance about a new pricing policy for road transport. SWOV has studied the report of the Joint Fact Finding working party with respect to road safety consequences. SWOV has also consulted the studies of your Transport Research Centre AVV on which the report is based. This letter describes our most important findings and makes recommendations for a possible sequence.

We are of the opinion that the advice of the Nouwen Commission is less easy to derive for road safety than the report suggests. 'Paying Differently for Mobility' will drastically change the traffic and transport system in the Netherlands. Depending on the chosen variant, there will be a shift in traffic: from working days to the weekend; from main road network to secondary road network; between freight carrying vehicles; and (in all variants) from car to bicycle, moped, or motorcycle. The road safety consequences are not simply in proportion with the less rapid growth of car use, as the advice maintains. SWOV identifies several large uncertainties and road safety risks, and we recommend taking these uncertainties into consideration in subsequent elaborations. It is our opinion is that there are good possibilities to do so, and we wish to offer you two advices:

1. The mobility consequences of 'Paying Differently for Mobility' have been studied in detail. This may be sufficient for determining the effects on accessibility but, from our viewpoint, it is insufficient for a good calculation of road safety effects. Therefore SWOV advises a more accurate calculation of the effects for traffic distribution as reported by the Platform.

A few explanatory remarks. Both the ultimate choice of the variant to be used, and the introduction path, can have a considerable influence on the road safety effects. SWOV advises mapping out these effects more clearly. We hereto recommend allowing room for compensatory measures for any negative road safety effects and to also attempt their quantitative estimates. Special points of attention here are the precise traffic redistribution by road type, other modes of transport etc., such as:

– Car and van mobility versus motorcycle mobility. Will car kilometres be replaced by motorcycle kilometres?
– Car mobility versus 'slow traffic' (bicycle, moped, light-moped, walking with and without a combination with public transport). Where will the extra bicycle/moped kilometres be made: which journey types, which infrastructure?
– Shifts between freight traffic: vans, lorries smaller than 12 tons, lorries larger than 12 tons, new extra large lorries. The resulting location of these changed transport modes is also important for the road safety effect.

– Shift from working days to weekend, which could possibly result from a congestion charge.
– Shift from the main road network to the secondary network. This could happen, for example, if the route is actually shorter along secondary roads or during an introduction phase. In that case it is very important that the secondary road network has a sustainably safe layout.

2. We have now roughly determined the road safety effects of the changed mobility. These effects depend on the chosen 'Paying Differently for Mobility' variant. SWOV advises to recalculate these effects.

By way of explanation we would like to note here that the presumed road safety effects have until now been determined roughly. Previous calculations for the Mobility Policy Document have been revised with minor adjustments. In our opinion, such a radical measure as proposed by the Platform justifies a more detailed analysis in which the road safety effect of the changing car and other transport mode kilometres is determined in detail. We advise you to also make the risk reduction of extra measures visible.

We would like to make a comment on the subject of making road management in the Netherlands independent; and this comment also applies to innovational contracts for design, construction, and maintenance of road infrastructure. The factual and political responsibility should both be guaranteed to promote road safety in general, and to ensure sustainable safety in particular, so that they will not be obstructed or delayed by these developments. If no sharp performance level is demanded, then road safety could be the victim. In SWOV's opinion the performance should not be measured in terms of numbers of casualties or in crash rates; after all it takes a long time before a performance is shown to be bad. Instead, there should be a minimum package of yet to be determined but beforehand testable road safety requirements. SWOV therefore advises you to be cautious about making road management independent.

The appendix to this letter discusses a number of findings. We briefly go into the calculations made with the Transport Research Centre AVV's National Model System which were described in the report entitled *Traffic effects of the variants for 'Paying Differently for Mobility'* (AVV, 29th March 2005). We then make a number of comments on the road safety analyses in *External effects* (AVV, 25 March 2005) and *Road safety policy options made visible* (AVV, 8 September 2004).

SWOV is of course more than prepared to contribute to the proposed further analysis.

Yours sincerely

F.C.M. Wegman
Managing Director

**Appendix to letter of 8th August 2005:**

**Findings concerning the results of the calculations using the National Model System.**

- The National Model System is meant for calculations of mobility/exposure on working days. The subdivision into journey purposes on working days is different from that at the weekend. We expect fewer calculated shifts in the weekend. Shifts from working days to the weekend can also occur if there is a congestion charge. It may be possible to calculate the volume of these shifts in another way than with the National Model System.
- Shifts from main roads to secondary roads will, in principle, not occur, according to the Platform, because it assumes that road pricing will replace Road Tax and CVT, and thus translates to all roads. It is thus only attractive to drive on a secondary road if the route really is shorter. Nevertheless, in variant 3 (a tax for lorries on main roads) a shift from main to secondary roads is anticipated. However, this shift is not quantified. In the SWOV report entitled *Bypasses for accessibility*: R-2004-6, we discuss the required changes in the secondary roads. If such shifts before the decision making about the introduction of 'Paying Differently for Mobility' are limited, this still means that accompanying policy measures will be necessary in those regions where, by exception, such shifts do occur.
- In variant 3 it is assumed that there will be no shift from heavy goods vehicles (>12 tons) to lighter lorries. SWOV doubts the validity of this assumption. In any case, if such a shift *did* happen, this can be bad for road safety.
- The National Model System takes into account individual trade-offs between extra journey time on a slow secondary road and the journey's low price because the distance is shorter. The National Model System also takes shifts to other transport modes into account, including no longer driving children to and from school. In some variants (extra congestion charge) the National Model System cannot calculate all that is required. In such a case an additional calculation is necessary.

**Findings concerning the calculations of the road safety effects.**

- If short distance car traffic is replaced by the moped, this can result in more dangerous traffic. This mobility change has been detected by the National Model System but the road safety consequences, although we expect them to be relevant, have not yet been calculated. SWOV gives into consideration that a shift from main to secondary roads must go together with investments in the sustainably safe character of the secondary roads. Likewise, a shift from car to bicycle kilometres must go together with investments in a sustainably safe infrastructure.
- The motorcycle can replace car kilometres if road users regard it a cheaper alternative. The Platform does not report clearly how this influences motorcycle use. The consequences of extra motorcycle kilometres are extremely significant for road safety.
- The road safety analyses only examined the effect of fewer kilometres on the main roads, in comparison with a reference value. No distinction was made between a car and a lorry. Such a distinction can indeed be important, especially in variants in which lorries are more heavily loaded. Depending on the chosen variants and conditions, the road safety effect can turn out either positive or negative.

- The road safety analyses assume the number of crashes to be proportional to mobility. Research has shown that such an assumption is not entirely correct. In order to be able to properly calculate the consequences of measures like those proposed by the Platform, a more refined method is required.
- The crash rates used (in various variants. for example such as being influenced by extra measures) have been adequately estimated by the Transport Research Centre AVV, but, nevertheless, the calculations could be improved. The main reason for this being that the calculations were made without taking into account the changed traffic system after the introduction of 'Paying Differently for Mobility'.