Socioeconomic Calculations for Winter Tires

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The socioeconomic consequences that may be expected from a ban on studded tires and the effects of a requirement on winter tires in certain periods during the winter or during slippery conditions were calculated and are presented. The requirement for winter tires (mud and snow tires) means that summer tires are not allowed, but both studded and unstudded winter tires may be used. The calculations were made for the winters of 1993–1994 and 1999–2000. The conditions for winter 1993–1994, a fairly normal winter, form the basis for the calculations. The conditions for 1999–2000 are the same except for the assumptions that all studded tires will have been replaced by tires with lightweight studs and that wear-resistant pavements will be more common. All other factors for 1999–2000, such as winter maintenance, are the same as for 1993–1994. A large part of the project was to calculate the changes in vehicle mileage with different tires in various winter road conditions.

The socioeconomic calculations include the following effects: (*a*) the traffic safety effects of ice and snow conditions and pavement wear; (*b*) road wear on pavement and road markings and subsequent sign cleaning; (*c*) car costs, including costs for tires and rims, changes in fuel consumption, and car-washing changes caused by the use of studs; and (*d*) environmental effects, which include only use of stronger agents for car washing when studs are used (other environmental costs are not included).

Sweden has 8.7 million inhabitants, 5.3 million of whom have driving licenses; there are 3.9 million vehicles (*1*). The total road length is about 415 000 km. Almost 100 000 km are state-administered roads and 38 000 km are municipal roads. The vehicle mileage is almost 70 billion vehicle-km (*2*). More than 80,000 accidents are reported by police annually. In 1993, 632 persons were killed in traffic accidents (*3*). The traffic safety level in Sweden is high as demonstrated by the following statistics:

- Persons killed per 100,000 inhabitants, 7.2;
- Persons killed per 10,000 vehicles, 1.6; and
- Persons killed per 100 million vehicle-kilometers, 0.9.

In socioeconomic calculations the accident costs are calculated according to the formula.

$$OLKOST = \left(a \times EO + b \times LS + c \times SS + d \times D\right)/ANTOL \quad (1)$$

where

EO = property damage
LS = slightly injured person
SS = seriously injured person
D = a fatality
$ANTOL$ = number of police reported accidents.
a = kronar (SKr) 100,000 ($15,150)
b = SKr 230,000 ($34,850)
c = SKr 5,400,000 ($820,000)
d = SKr 12,100,000 ($1,830,000)

U.S. dollar conversions are at August 1, 1996, rates. The costs, including human value, are according to the 1992 price level of a police-reported accident. The av-

erage accident cost for the whole year is for rural areas SEK 1,300,000 and in urban areas SEK 520,000. The costs include an estimate of the accidents that are not reported to the police. In winter the average accident cost is somewhat lower.

Winter Tire Project

During winter 1993–1994, the Swedish National Road Administration received considerable criticism for its winter maintenance, in particular for the high consumption of road salt. This led to discussions on changing the rules for winter maintenance, allowing a little ice and snow on salted roads and performing maintenance on more roads without salt. In addition, changes intended to influence vehicle equipment and driver behavior were to be studied.

The purpose of the investigation described here was to calculate the socioeconomic consequences that may be expected from a requirement on winter tires in various circumstances. The study started with a calculation of the socioeconomic consequences that may be expected from a ban of studded tires (*4*). That calculation was made to compare with earlier calculations (*5,6*). In this paper that result is transformed into the effect of the use of winter tires (with or without studs) in the winter compared with the effect if all cars used summer tires. The calculations were made for winter 1993–1994 and for winter 1999–2000. The conditions in winter 1993–1994, a fairly normal winter, form the basis for the calculations. During that winter it is estimated that 17 percent of the vehicles with studded tires had lightweight studs. The conditions in 1999–2000 are the same, except it is assumed that studded tires will have been replaced by tires with lightweight studs and that wear-resistant pavements will have become more common. All other factors, such as winter maintenance, are the same as for 1993–1994.

Several effects were studied, as follows.

- Accidents (direct, because of slippery pavement; indirect, because of pavement wear);
- Road wear (pavement and road markings, dirty signs);
- Car costs (tires and rims, fuel consumption, washing); and
- Environment (car washing).

Effect of Winter Tires Versus Summer Tires

The proportion of cars and the proportion of vehicle mileage (in ice and snow) using different tires are shown below:

	Cars (Percentage) %	*Vehicle Mileage on Ice/Snow (Percentage)*
Studded tires	64	76
Studless winter tires	13	15
Summer tires	23	9

When studded tires are used, the effects on road safety are a 40 percent decrease in accidents in icy or snowy road conditions on rural roads and a 35 percent decrease in accidents in built-up areas compared with use of summer tires. The corresponding figures for other winter tires are 25 percent and 20 percent. Each type includes both good and bad tires in use at the beginning of 1990 (*7,8*).

The number of car accidents in icy or snowy conditions during winter 1993–1994 was 16,271. The following may be calculated:

Number of car accidents in icy or snowy conditions if all cars have summer tires	23,848
Number of car accidents in icy or snowy conditions if studded tires are banned	19,538

The results obtained on the use of winter tires indicate an accident decrease of just more than 7,500 accidents per winter. There are also indirect accident effects caused by the use of studded tires, such as higher wet friction on pavements, because studs create a coarse surface texture and produce wheeltracks and dirt spray (*9,10*). The sum of these indirect effects is decrease of 600 to 700 accidents because of the use of winter tires. The number of fatalities in road accidents has decreased somewhat, by about 40, the seriously injured by around 350, and the slightly injured by about 1,500. The values are uncertain.

For measurement of road wear from traffic with studded tires, the SPS index normally is used. SPS is the Swedish abbreviation for specific wear and indicates the number of tonnes of abraded asphalt per kilometer of road and million vehicles with studded tires, or the number of grams of abraded asphalt per kilometer of road and vehicle with studded tires. The average SPS index has been calculated after measurements on roads with various annual average daily traffic values. With steel studs, the SPS index varied between 22 and 35 g/km for the various classes of traffic, with an average of 26 g/km. The SPS index for lightweight studs is half this figure (*11*).

During winter 1993–1994, it is estimated that 17 percent of the vehicles with studded tires had lightweight studs. This gives a weighted SPS index of 24 g/km, which implies total wear of 300 000 tonnes, valued at approximately SEK 150 million. To compensate for winters with more troublesome wear levels, the cost of wear can be

said to be in the range of SEK 150 million to 200 million. Costs of wear on road markings and the washing of dirt spray from road signs is estimated to cost SEK 35 million to 70 million a year.

In 1999–2000, when all studded tires will have lightweight studs and wear-resistant pavements are more common, the average SPS index is calculated to be 11 g/km, giving total road wear of about 130 000 tonnes, worth SEK 65 million to 90 million at today's prices. Costs of wear on road markings and the washing of dirt spray from road signs is put at SEK 20 million to 35 million a year.

Compared with use of summer tires the whole year, the costs of motorists' using winter tires have increased. The motorist pays for winter tires and extra rims and the cost of wheel changing. The annual cost will be about SEK 330 million.

Petrol consumption is calculated to increase by SEK 90 million because of an assumed difference of 2 percent between summer tires and winter tires. It is also assumed that no difference exists between studded and studless winter tires.

The use of studded tires means that vehicles must be cleaned more often because road wear will increase. In this study, two calculations are made. The first is that studs necessitate two to four extra washes during a winter, and the second is that all 13 washes during the winter take somewhat longer and that half an extra wash is required. The first alternative gives a somewhat larger dispersion in costs and this alternative is therefore the one used. It entails a cost to car owners of SEK 300 million to 700 million, which could be avoided. Because of road wear in 1999–2000, the cost will be only SEK 130 million to 300 million.

Vehicle washing requires stronger agents than would be necessary if tire studs were not used. Emissions of petroleum-based solvents attributable to use of studded tires would then amount to 1500 to 3000 tonnes for 1993–1994. On the basis of the Swedish National Road Administration's environmental valuation, this would lead to an environmental cost of SEK 25 million to 50 million a year. In 1999–2000, the environmental cost of vehicle washing necessitated by the use of studded tires will have fallen to SEK 10 million to 20 million.

The effect of winter tires on accidents is considerable, and the benefit of the decrease in accidents due to the use of such tires is not offset by other cost increases. The effect on the environment, however, is difficult to measure and evaluate, and therefore only vehicle washes are included in Table 1. With the results for the other effects, this means that the total environmental effect may become fairly large before equilibrium is reached. In or near 2000, the difference between the advantages and disadvantages of winter tire use will be even greater. The lightweight stud will then be the only type of stud available, leading to lower car and wear costs and thereby a reduction in environmental effects, at the same time as the effect of studded tires on road safety is maintained.

TABLE 1 Cost Changes, Winter Tires (Studded or Unstudded) Versus Summer Tires (in SKr Million/Year)

	Decrease	Increase	
		1993/1994	1999/2000
Accidents			
– direct	2,750–3,370		
– indirect	240–290		
Road wear			
– pavement		150–200	65–90
– road markings		35–70	20–35
signs			
Car costs			
– tires/rims		330	330
– fuel consumption		90	90
– washing		300–700	130–300
Environment			
– car washing		25–50	10–20
– the rest		?	?
TOTAL	2,990–3,660	930–1,440 +?	645–865 +?

Requirement for Winter Tires in Slippery Conditions

In the case of a requirement for winter tires in slippery conditions, it is possible that all vehicle mileage with summer tires on ice and snow will be eliminated; vehicle mileage with summer tires in icy or snowy conditions will be replaced by travel in bare road conditions; and motorists will change to winter tires.

In the calculations (*12*), the requirement for use of winter tires is compared with the use in the winters of 1993–1994 and 1999–2000 (Table 2). Most often, minimum and maximum alternatives for a redistribution of the vehicle mileage are calculated. It is then possible to interpolate between these alternatives. The distribution of vehicle mileage among different tires controls the change in benefit-cost implied by the various alternatives, on the basis of conditions in winter 1993–1994. The distribution used here is that of the 23 percent of drivers that now use only summer tires in the winter, 15 percent will use stud-

TABLE 2 Projected Changes Under Requirement for Winter Tires on Slippery Surfaces Compared with Tire Use in Winter 1993–1994

	Decrease	Increase	
		1993/1994	1999/2000
Accidents			
– direct	385–485		
– indirect	75–95		
Road wear			
– pavement		25–35	10–15
– road markings/signs		10	5
Car costs			
– tires/rims		200	200
– fuel consumption		30	30
– washing		50–120	20–50
Environment			
– car washing		5–10	0–5
– the rest		?	?
TOTAL	460–580	320–405 +?	265–305 +?

ded tires, 5 percent will use winter tires, and 3 percent will not drive when the roads are slippery.

The road safety benefit of this requirement is greater than the known negative effects of the requirement. When slipperiness is unexpected it is possible that some vehicle mileage with summer tires will take place, which will decrease the highest traffic safety value in Table 2. The number of car accidents reported by the police will decrease by 1,100 to 1,400, the number of persons killed in traffic by 6 to 7, the number seriously injured by 50 to 60, and the number slightly injured by 200 to 250. The values are uncertain.

Conclusions

The requirement for winter tires in slippery conditions will, compared with the use of summer tires, cause a decrease in accident costs by SEK 3,450 million to 4,240 million a year. The increase in costs for roads, cars, and the environment (considering only car washing) will be SEK 1,250 million to 1,845 million in 1993–1994 and SEK 910 million to 1,170 million in 1999–2000.

The decrease in police-reported accidents will be about 9,200 to 9,600 per winter. This is a winter reduction of more than 20 percent.

As a result of this project, the government suggested that winter tires be required during slippery conditions. The suggestion has been referred to authorities for consideration, and a decision will follow.

Acknowledgment

This work was sponsored by the Swedish National Road Administration.

References

1. Statistical Yearbook of Sweden 1994. Statistiska centralbyrån. In English.
2. Thulin, H., and G. Nilsson. *Vägtrafik, exponering, skaderisker och skadekonsekvenser för olika färdsätt och åldersgrupper (Road traffic, exposure, injury risks and injury consequences for different travel modes and age groups)* (English summary). Rapport 390. Statens Väg- och transportforskningsinstitut, 1994.
3. *Nationellt trafiksäkerhetsprogram, 1995–2000 (National Traffic Safety Program, 1995–2000)* (in Swedish). Vägverket, Rikspolisstyrelsen och Svenska Kommunförbundet.
4. Carlsson, A., P. Centrell, and G. Öberg. Studded tyres. Socio-economic calculations (in English). Statens Väg- och Transportforskningsinstitut. Meddelande 756A.
5. Carlsson, A., O. Nordström, and H. Perby. Effekter av dubbdäck. Konsekvenser av ändrade bestämmelser (The effects of studded tyres. Consequences of amended regulations) (English summary). Statens Väg- och Trafikinstitut. Meddelande 674.
6. Piggdekk og vintervedlikeholdsstrategi. (Studded tyres and winter maintenance in the Nordic Countries) (English summary). Nordisk Vegteknisk Forbund, Rapport nr 6, 1992.
7. Öberg, G., O. Junghard, and M. Wiklund. En studie av metoder för att beräkna samband mellan dubbdäcksanvändning och trafiksäkerhet (A study of methods of calculating the connection between the use of studded tyres and road safety) (English summary). Statens Väg- och Trafikinstitut. Meddelande 722.
8. Nordström, O., and E. Samuelsson. *Vinterdäcks väggrepp på is (Road grip of winter tyres)* (English summary). Rapport 354. Statens Väg- och Trafikinstitut.
9. Kallberg, V.-P. *Uuden, vähan tietä kuluttavan nesta tyypin vaikututs liikenteen käyttö—kustannuksiin (The effects of a new stud type on the running costs of road traffic)* (in Finnish). Meddelande 914. Statens Tekniska Forskningscentral, Väg- och trafiklab., 1988.
10. Hemdorff, S., et al. *Trafiksäkerhet och vägytans egenskaper (TOVE). Slutrapport (Traffic safety and the properties of road surfaces. Final report)* (English summary). Statens Tekniska Forskningscentral. Meddelande 1075, 1989.
11. Gustafson, K. *Prov med lättare däckdubb i VTIs provvägsmaskin (Test with lightweight studs in the VTI's pavement testing machine)* (English summary). Rapport 377. Statens Väg- och Trafikinstitut.
12. Carlsson, A., and G. Öberg. *Winter tyres. Effects of proposed rules* (in English). Statens Väg- och Transportforskningsinstitut. Meddelande 757A.