Transport analysis

External costs of traffic in Sweden with a European outlook, 2015

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Report 2015:4

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Summary

The Swedish Government has commissioned Transport Analysis to report annually on the social marginal costs of traffic in relation to taxes and other charges in various parts of the Swedish and European transport sector. The costs analysed are primarily the short-run social marginal costs of the external effects of traffic.

This year's report highlights the importance of differentiating marginal costs and pricing geographically, in time, and by vehicle type. With a European perspective, we explain how marginal costs are balanced by taxes and charges for freight shipments along two routes through Europe. Further, the report discuss the cost of carbon dioxide and how to handle other green-house gas emissions from air traffic. Finally we look into the future and discuss the marginal cost of external effects towards 2040, will they increase or decrease?

The estimated marginal costs of external effects are incomplete in some respects and this is especially the case concerning maritime transport and aviation. Some further geographical differentiation are needed. With new technology, new infrastructure, improvements in existing infrastructure and with increased traffic the external effects from traffic will change over time. With changes in welfare, income and preferences the valuation of external effects will also change. The calculation of the marginal external costs are based on relevant and reliable new research from the Swedish National Road and Transport Research Institute (VTI).

The effects of traffic (e.g., fuel consumption, vehicle wear, travel time, accidents, air pollution, comfort, and accessibility) can be either external or internal. An effect is internal if the market actors (e.g., car drivers, transport operators, shippers, and travelers) recognise them, when deciding if and how to undertake a trip or shipment. When these effects are not recognised, they are external. The external marginal costs not taken care of by regulations or technical development can be *internalised* through taxes or charges. This means that the actors are persuaded to act as if they recognised the external effects. They are prevented in an "artificial" manner from the over-consumption that would normally result when not all transport costs are recognised. When the degree of internalisation is 100 percent, the marginal costs and the corresponding taxes and charges are equal.

The European perspective

2012 Transport Analysis initiated a study of the rate of internalisation in two European freight corridors for road, rail, and sea transport in Europe[1], and we have since then followed the development. The study is based on two presumed freight corridors, between Norway (Narvik) and Italy (Naples), and between Norway (Oslo) and the Netherlands (Rotterdam). For each corridor, routes for the different modes of transport are shown in figure 1. The analysis is further differentiated on a national level, where each country constitutes one segment of the transport. The calculations are, among other things, based on valuations of external costs as reported in the EU-project IMPACT, including a European value of carbon dioxide that is lower than the official Swedish valuation. The background of the IMPACT Handbook is a request by the European Parliament in the previous version of the Eurovignette Directive for the EU Commission to present an analysis of external costs. Looking back 20 years, it should be

[1] Anna Melin, et.al. (2013), Internalisation of External Effects in European Freight Corridors, Discussion Paper No. 2013-10, International Transport Forum, OECD.

noticed that the Commission step by step have had the intention to harmonise the transport pricing policy over the EU member-states and also that internalisation of external costs for all modes of transport is an important issue in EU. It hereto seems to be the intention to earmark the collected taxes and charges and use it to develope the transportsystem.

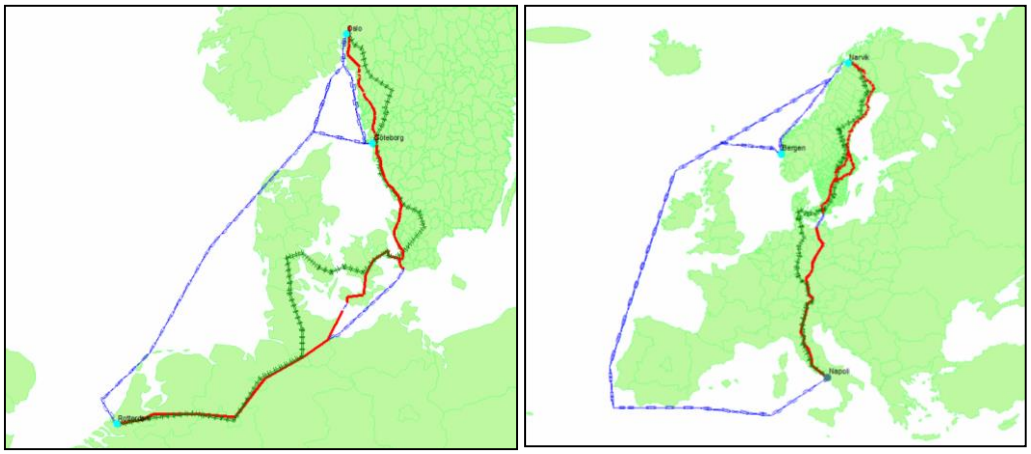

Figure 1: Studied transport routes ´by mode between Oslo and Rotterdam, passing Gothenburg and routes for the different modes between Narvik and Naples. (SEA, ROAD, RAIL)

From the European perspective, Sweden has relatively low internalising taxes and charges on freight transport in the studied corridors toward Rotterdam and Naples.

The degree of internalisation of the Swedish portion of the Oslo-Rotterdam railway line, for example, have raised from 50 to 60 percent between 2012 and 2014, but are still low compared with the average of 133 percent for the entire route. Table 1 gives the same picture in the Narvik-Naples railway corridor. The rail-track charges have increased in all countries since 2012 except for Italy and the degree of internalization for the entire route have thus increased from 84 to 103 percent.

Tabell 1: Degree of internalisation in the route Narvik-Naples 2014 for freight-trains (960 gross tonne).

Segment	***Country***	***Distance km***	***Total costs (€)***	***Total charge (€)***	***Degree of internalisation***
Narvik-Riksgränsen	NO	40	75	161	216 %
Riksgränsen-Öresund	SE	2 012	3 765	1 762	47 %
Öresund-Padborg	DK	340	652	1 293	198 %
Padborg-Kufstein	DE	875	1 690	2793	165 %
Kufstein-Brennero	AU	106	195	371	191 %
Brennero-Naples	IT	760	1 445	1 713	118 %
Total		4 133	7 822	7759	103 %

On the road side, the difference in taxes and charges depends primarily on whether the Eurovignette system or road tolls are applied, with countries that apply a road toll having a significantly higher degree of internalisation (e.g., Austria and Germany).

For heavy trucks, Sweden and Norway have the lowest degrees of internalisation of the European countries. In the route Narvik-Naples, the degree of internalisation are slightly over 50 percent in Sweden and lower in Norway compared to the average for all countries somewhat under 100 percent, as can be seen in table 2. Comparing the situation with 2012, the major change is that the charge to pass the Brenner-tunnel have increased each year.

Tabell 2: Degree of internalisation 2014 in the route Narvik-Naples for heavy trucks (40 tonne EURO Class IV).

Segment	***Country***	***Distance km***	***Total costs (€)***	***Total charge (€)***	***Degree of internalisation***
Narvik-Riksgränsen	NO	48	20	8	41 %
Riksgränsen-Västerås-Trelleborg	SE	1 964	685	352	51 %
Riksgränsen-Stockholm-Trelleborg	SE	2 009	648	351	54 %
Trelleborg-Rostock	Ferry	154	29	17	58 %
Rostock-Kufstein	DE	869	163	271	166 %
Kufstein-Brenner	AU	109	18	135	747 %
Brenner-Naples	IT	922	210	264	126 %
Total (by Västerås)		4 066	1 125	1 047	93 %
Total (by Stockholm)		4 111	1 088	1 082	99 %

On European routes, maritime transport is heavily under-internalised, the degree of internalisation being in the range between 0 and 8 percent. External costs for maritime transport consists mainly of emissions including carbon dioxide at the same time as the internalising taxes and charges are limited to the fairway dues in Sweden and the nitrogen dioxide charge in Norway.

External costs of traffic in Sweden

The degree of internalisation is a relative (i.e., unit-less) measure and, as such, can easily be misleading unless the absolute level of internalisation is also taken into consideration, particularly in comparisons where external effects differ greatly in size. Calculations of non-internalised costs can also give an idea of the amount by which internalising taxes and charges need to be raised to achieve full internalisation. Since the marginal costs of increased congestion have not yet been estimated, calculations can only be made for traffic in environments that lack significant congestion. Transport Analysis' most present calculations, assuming no significant scarcity or congestion, result in the degrees of internalisation shown in table 3. Our findings are also summarized in words after table 3.

Table 3: Non-internalised external costs in SEK per passenger-km respective SEK per tonne-km in Sweden 2014. Degree of internalisation within brackets. Scarcity on tracks and congestion costs not included.

	Rural areas	***Population centres***	***Average***	***Comments***
Passenger traffic				
Car, petrol	-0.08 (141 %)	0.16 (66 %)	0.01 (96 %)	1.5 travellers/vehicle
Car, diesel	0.01 (95 %)	0.27 (43 %)	0.12 (62 %)	1.5 travellers/vehicle
Bus, diesel*	0.06 (63 %)	0.21 (43 %)		12 travellers/vehicle
Train, railtrack-charge Base	(0.022) [1] (66 %)	0.04 (51 %)		[1] = low noise
Train, railtrack-charge High		-0.004 (105 %)		Including peak-period passage-fee in large urban areas
Train, railtrack-charge Average			0.00 (102 %)	
Passenger ferry			0.07 (82 %)	Example, one type of ferry
Air transport			0.40 (45 %)	Example, distance 400 km, including climate effects
Freight traffic:				
Pick-up, diesel	-0.01 (103 %)	0.40 (47 %)	0.15 (70 %)	Average load 1 tonne
Heavy truck without trailer	0.15 (57 %)	0.59 (27 %)	0.27 (43 %)	Average load 4.3 tonne
Heavy truck with trailer	0.05 (65 %)	0.16 (47 %)	0.08 (57 %)	Average load 17.4 tonne
Train, railtrack-charge Base	(0.037) [1] (25 %)	0.044 (22 %)		[1] = low noise
Train, railtrack-charge High		0.035 (37 %)		Including peak-period passage-fee in large urban areas
Train, railtrack-charge Average			0.035 (34 %)	
Freight ships			0.027 (55 %)	Not including ice breaking and port costs **

* Remaining non-internalised external costs for biogas-fuelled city-bus are SEK 0.19 per passenger-km, that is just about the same as for diesel-bus. Biogas generates no external costs for carbon dioxide and other emissions, but does on the other hand not pay any internalising fuel-taxes. The degree of internalisation is 0.

** With assistance of an ice-breaker, the non-internalised external costs will increase by SEK 0.04 per tonne-km.

- Heavy truck transports is the type of freight transport in Sweden that to the least extent pays for its total social marginal cost per tonne-km. The non-internalised cost of heavy truck transport is between SEK[2] 0.05 to 0.65 per tonne-km (2014 price level). The lower cost applies to trucks on larger national roads far from population centres and the higher cost are generated by trucks on national roads around urban areas. In urban areas with more population close to the roads, the marginal costs might be even higher. The interval corresponds to SEK 0.7 to 3 per vehicle-km. The degree of internalization is in the range of 25 to 70 percent, implying that heavy truck transport pays at most 70 percent of its external costs on non-congested roads.

- Freight transport by rail has non-internalised external costs of approximately SEK 0.03–0.04 per tonne-km. In other words, freight trains are close to covering their total social marginal costs at least in comparison with some heavy road transport. Still, the degree of internalization is in the range of only 20 to 40 percent, implying that freight shipped by rail pays between 20 and 40 percent of their (fairly low) external costs.

- Also freight transport by ship has low non-internalised external costs (SEK 0.03) per tonne-km. This corresponds to a degree of internalisation around 50 percent.

- For passenger transport by car, the degree of internalisation differs substantially between petrol- and diesel-fuelled vehicles. Petrol-fuelled car in rural areas is a type of transport that more than fully pays its estimated total social marginal costs. In population centres, however, the environmental costs are greater, as more people are affected by air pollution and noise, resulting in a non-internalised external cost of SEK 0.15 per passenger-km. The degree of internalisation is 70 percent in population centres, 140 percent in rural areas and slightly less than 100 percent on average for petrol-fuelled cars. Diesel-fuelled cars almost pays for its total social cost in rural areas, but due to higher environmental costs they pay much less in population centres also compared to petrol-cars. The remaining non-internalised external costs in population centers are estimated at SEK 0.3 per passenger-km for trips by diesel-fuelled cars, and the degree of internalisation is slightly higher than 40 percent there. The degree of internalisation for diesel-fuelled cars, as a national average, is just over 60 percent.

- Passenger transport by rail have remaining non-internalised external costs close to zero. It varies between SEK 0 and 0.04 per passenger-km. Long distance passenger trains can in many respects be said to pay for the external costs they cause. One exception is on infrastructure with capacity problems.

- Transport by bus pays for its total social cost to a lesser degree than passenger trains. Remaining non-internalised external costs for bus in urban areas are SEK 0.2 per passenger-km and around SEK 0.06 per passenger-km in rural areas.

[2] 10 SEK ≈ 1 EUR

- Air transport have large costs for emissions and green-house gases, were the latter is caused both by carbon dioxide and other emissions on high altitude. Including an adjustment for high altitude emissions the remaining non-internalised external costs are around SEK 0.4 per passenger-km and the degree of internalisation slightly less than 50 percent. It is argued that since flights in EU is included in ETS (the Emission Trading Scheme), the cost of carbon dioxide should not count. Excluding all green-house gas emissions and effects on high altitude, results in a degree of internalisation around 100 percent. The calculations are based on an example flight and rest on some other uncertain judgments. There is a need for new research and better knowledge in this field.

Climate policy implicitly reflects how we view the marginal cost of carbon-dioxide emissions. Transport analysis argue that the same marginal cost for carbon dioxide slightly above SEK 1 per kg should be applied to all modes of transport.

Looking toward 2040

Many factors affect the marginal costs of the external effects from traffic towards 2040. Technical development of vehicles and infrastructure typically lead to lower marginal costs for several cost components. Higher incomes and a higher population density close to infrastructure on the other hand, results in increased valuations of remaining noise, air pollution and accidents.

Swedish GDP per capita is forecasted to increase by 32 percent to 2025 and by 60 percent to 2040. A larger decreases of emissions, noise and accident risks can balance the impact of rising values of marginal costs. Whether the expected improvements of vehicles and in infrastructure is sufficient to counteract the effect of increased values and higher population density depends on vehicle type and where the traffic is taking place. Air pollutants such as nitrogen oxides and exhaust particulate matter (PM) from road traffic is expected to decrease so much that it most certainly will result in reduced marginal costs in the future. When it comes to noise the picture is more multi-faceted. It is for example possible to upgrade brakes on many freight trains and significantly reduce the noise, while it may be a greater challenge to reduce noise from passenger trains. However, noise reducing measures on both road and rail (vehicles and infrastructure), and a growing proportion of road traffic driven on electricity in urban areas may still offset the impact of higher valuation of noise and an increasing population to be disturbed by noise.

Existing knowledge regarding external effects for maritime transport and aviation are not as updated as for road and rail traffic. It can, however, be noted that for maritime transport, the marginal cost of emissions and carbon dioxide may decrease while we not can foresee any major changes in marginal costs for aviation either to 2025 or 2040. Further research to sort out issues concerning climate effects and emissions on a high altitude will be of importance.

A potential for future research

Transport Analysis would like to stress that the application of internalisation requires analysis of estimations and valuations of many effects associated with uncertainties of various types. All results should therefore be interpreted with caution. The main points of the results presented here can, however, be considered robust, but will be updated during coming years as knowledge develops.

The reported marginal costs and taxes and the calculations of remaining external costs consist largely of average values for different transport modes and for both passenger and freight transport. The spread around the average values we use in our calculations can, as demonstrated, be significant, and depends on geography and on type of vehicle. Certain transport users or operators may end up paying too much and others too little in relation to the external effects caused by a particular trip or shipment. The goal is, however, to determine the right price for each trip or shipment. At the same time, the charging systems should not be so complicated that users cannot easily understand their overall structure, otherwise the systems are likely to lose their ability to change behavior. Analysing internalisation and calculating remaining external costs, the cost data used should be as differentiated as possible. The differentiation should primarily consider geography, time, and vehicle type. Updated and quality assured differentiated marginal costs are necessary to enable differentiated taxes and charges that might function as relevant instruments to adjust behavior and give incentive for technical change.

Apart from road wear, which varies geographically and depends on vehicle type, noise cost also has a strong geographic connection. Noise disturbs people, so its cost is significantly higher in population centers. Finally, congestion also displays strong geographic and temporal variation. On the road side, congestion fees have been introduced in Stockholm and Gothenburg; however, there is still no actual congestion charge on the railway side, despite congestion and an awareness of its existence. The marginal external congestion cost is still not estimated.

On the railway side, noise and track wear and tear should be differentiated on the appropriate route level for different train types. On the road side, both environmental (including noise) and road wear-related characteristics should be determined for different heavy vehicles for, say, two or three road types.

Geographically differentiated environmental effects are needed in a useful way applicable (for pricing policy) in the real world. There is also a lack of knowledge of marginal cost for accidents and environmental effects including noise in urban areas beyond the national roads.

The external costs of sea transport relate primarily to air pollution and carbon-dioxide emissions, and knowledge about emissions from sea vessels of different sizes must be updated and/or quality-assured. The cost of these emissions are also in need of updating and clarification.

On the air transport side, the cost of emissions and greenhouse gases accounts for a major part of the external costs. It is therefore essential to understand more about how these emissions and climate-effects are to be valued and calculated.

Transport analysis

Transport Analysis is a Swedish agency for transport policy analysis. We analyse and evaluate proposed and implemented measures within the sphere of transport policy. We are also responsible for official statistics in the transport and communication sectors. Transport Analysis was established in April 2010 with its head office in Stockholm and a branch office in Östersund.

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