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Track access charges: reconciling conflicting objectives

Case Study – Sweden: Track access charges and the implementation of the SERA directive - promoting efficient use of railway infrastructure or not?

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Table of contents

1. Background

This study is concerned with the way in which track user charges promote (or not) the efficient use of railway infrastructure in four of the European Union's member states. Section 2 of this mimeo describes 2017 track user charges in Sweden, implemented within the common European framework established by the SERA Directive (2012/34/EU). Section 3 thereafter provides state-of-the-art information about the social marginal costs for using this infrastructure while section 4 compares 2015 marginal costs with track user charges that year.

Due to volatile exchange rates, the costs and revenue in SEK have not been adapted to Euro. The approximate exchange rate is, however, SEK 10=€1, making all conversion simple.

2. Charges, Revenue and Financial Costs

The Swedish Railway Act (2004: 519) is Sweden's version of the SERA Directive. The infrastructure manager, the Swedish Transport Administration (subsequently the IM or Trafikverket) administers the collection of charges and regularly makes changes of levels and charging structure. At the request of the government, and after several years of preparations, Trafikverket published a report in 2014 that establishes a plan for the level and structure of charges for using the infrastructure for the years to come (Trafikverket report 2014:074). The report provides the framework for current levels of charging and establishes a trajectory of annually increasing charging levels.

This section first describes the level and structure of the minimum access package for using the infrastructure (section 2.1). This is published as part of each year's Network Statement.[1] Section 2.2 presents total revenue from these charges as well as aggregate spending on railway infrastructure and section 2.3 provides a brief description of a complementary dimension of the SERA directive, namely Sweden's version of a Performance Scheme and the role of the regulator.

2.1 The Minimum Access Package[2]

The purpose of the track charge is to reflect the short-run marginal cost for infrastructure wear caused by traffic. The basic principle is to differentiate the charge, to account for the fact that different vehicles may cause different degree of wear. In this way, users are given reasons to contemplate the choice of rolling stock, i.e. to consider if they have reasons to purchase locomotives and cars that inflict less wear, in that way paying lower track charges. This illustrates how the track charge may contribute to improving the functionality of the transport system.

Table 1 summarises the 2017 track charge. It is based on gross ton-kilometres, and is imposed at varying amounts for both freight and service trains and for passenger traffic. It is also differentiated for the maximum axle load of the train. Trains with a higher axle load thus pay a higher track charge. The level of track charges was previously based on estimates of trains' wear and tear costs for track maintenance (excluding renewal costs). It is not clear what the rationale is for the current charging structure.

The purpose of train path and passage charges is to differentiate the cost for using the infrastructure over time and geography, in that way contributing to the efficient use of existing track capacity. The passage charge contributes to the efficient use of infrastructure by making it

[1] https://www.trafikverket.se/contentassets/b6f27615be234f1fababa0b1f25196dd/network_statement_2017_edition_20151210.pdf

[2] The motives given for the level and differentiation of charges are taken from the original documents. The ability of the current structure to fulfil the stated objectives is addressed in section 4.

costlier to operate trains at places where there are peaks in capacity use during some time periods of the day. In principle, the train path charge should also account for whether the train operators' original demand for slots has been met.

Table 1: Track charges 2017, SEK per gross ton km

	Highest Axle Load, ton	Charge
Freight and service trains	load<20	0,0056
	20<load≤22,5	0,0070
	22,5<load≤25	0,0077
	Load>25	0,0084
Passenger trains	load ≤20	0,014
	load >20	0,0154

The three-level train path charge is based on train kilometres and differs with respect to the degree of capacity utilisation (see Table 2). Railway lines marked with red in Figure 1 are in high demand and are charged more while the lines in green are in low demand. This categorisation changes over time and Table 3 illustrates how specific track sections have been re-defined between the years 2016 and 2017. The change from red to yellow or green (or the other way around) emanates from variations in the demand for slots between years. The changes may emanate from the fact that operators adjust the way in which some services are operated, from the fact that sections of tracks have been upgraded or new sections added, etc. This establishes that the differentiation emanates from scarcity concerns rather than being a means for revenue maximisation.

Table 2: Train path charge, 2017, SEK per train km

	High	Medium	Low
All types of trains	6,30	2,30	1,90

Trains using tracks in Stockholm, Gothenburg and Malmö during three hours in the morning or three hours in the evening on non-holiday weekdays are charged an extra SEK 416 (€43.79) per train passage. Maps (not included here) detail precisely which parts of the network in the cities are charged the extra levy. No evidence is given on the source of the numbers for the differentiated path km charges and the peak surcharges around major cities. It is therefore reasonable to say they are based on judgement.

The emissions charge is based on the socioeconomic costs in terms of environmental and health effects generated by the operation of an additional train that is not operated by using electricity. About five percent of total train kilometres operated in the country per year belong to this category. The size of the charge depends partly on the engine's environmental classification and partly on the amount of fuel consumed in the way summarised in Table 4.

Trafikverket (2014) states that a charge to account for accident risk is difficult to differentiate in a meaningful way. Since there is no corresponding levy for road users, Trafikverket suggests that accident risk is not part of the charging scheme. In addition, the 2014 report also indicates that noise from rail traffic generates a high cost to the environment and that the variation in costs is substantial. Since the Commission has not established the principles for charging for noise, Trafikverket abstains from implementing this type of charge.

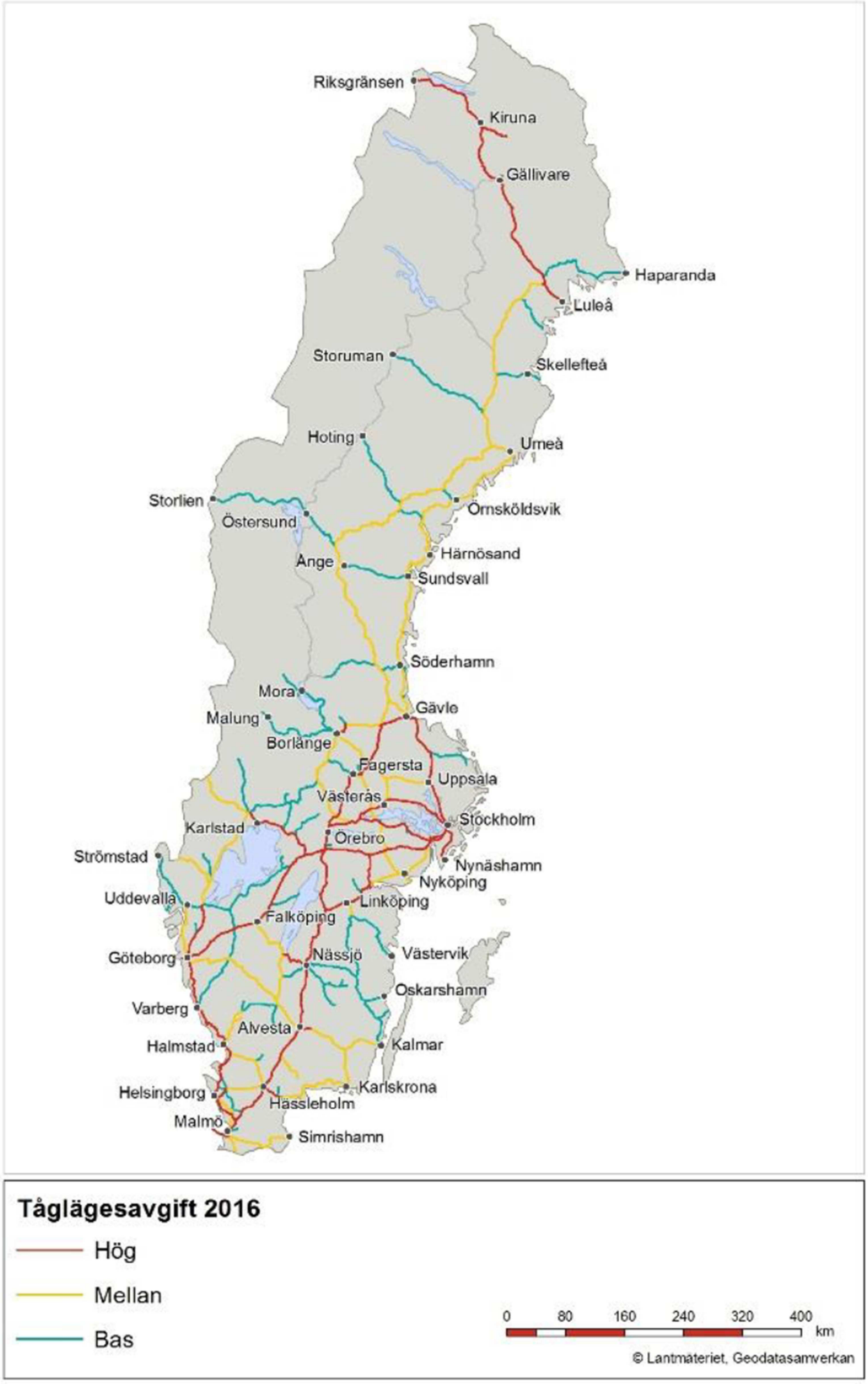
Freight trains that use the Öresund Link between Sweden and Denmark pay a passage charge at SEK 2,980. These trains don't pay track charges and train path charges for this section of the journey.

Table 4: Emission charges for vehicles using diesel or gaseous fuel

	Compression ignition engine		**Spark ignition engine**	
	SEK (€)/litre*	SEK (€)/m3**	SEK (€)/litre*	SEK (€)/m3**
Locomotive, base	3,20	3,76	2,14	2,71
Locomotive, envir. classification Stage IIIA	2,07	2,43	2,07	2,43)
Locomotive, envir. classification Stage IIIB	1,66	1,95	1,66	1,95
Railcar, base	3,13	3,68	2,07	2,62
Railcars, envir. classification Stage IIIA	1,72	2,02	1,72)	2,02
Railcars, envir. classification Stage IIIB	1,42	1,66 (	1,42	1,66

* Liquid fuel ** Gaseous fuel

Figure 1: Chart describing the level of demand for access to Sweden's railway network



Legend: Red lines are in high demand and green lines have little traffic only.

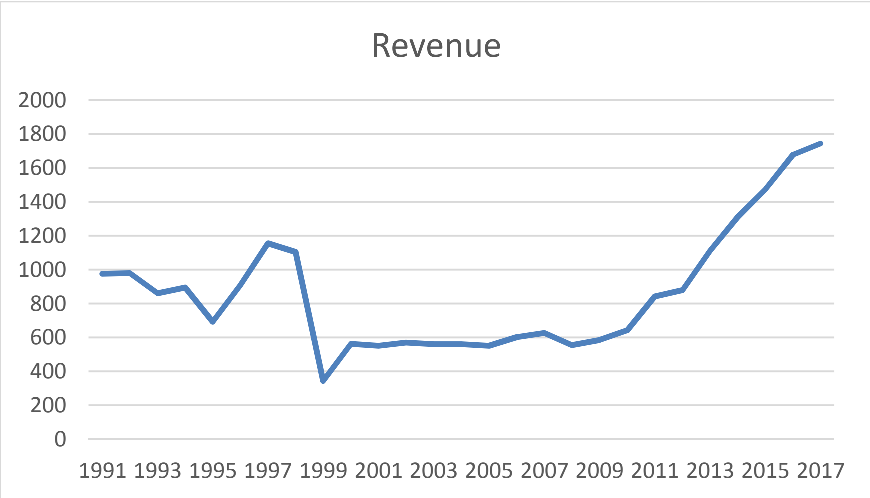
Table 3: Change of track section categorisation between 2016 and 2017

Lines with changes	Tåglägesavgift 2016	Tåglägesavgift 2017
Citybanan Karlberg - Stockholm S		
Södertälje H - Järna (ev. åtgärda för 2015 och 2016)		
Järna – Nyköping		
Nyköping – Åby		
Storvik - Avesta/Krylbo		
Avesta/Krylbo – Fagersta		
Fagersta – Frövi		
Frövi – Hovsta		
Gävle – Storvik		
Öxnered – Vänersborg		
Bålsta - Västerås N		
Västerås N - Västerås C		
Västerås C – Kolbäck		
Kolbäck – Valskog		
Valskog – Arboga		
Arboga – Hovsta		
Södertälje – Nykvarn		
Nykvarn – Läggesta		
Läggesta – Eskilstuna		
Eskilstuna – Folkesta		
Folkesta – Rekarne		
Rekarne – Valskog		
Åkers Styckebruk – Grundbro		
Älvsjö – Västerhaninge		
Västerhaninge – Hemfosa		
Hemfosa – Nynäshamn		
Östervärn – Fosieby		
Fosieby – Lockarp		
Emmaboda – Karlskrona		

2.2 Revenue and spending

The expected revenue from track user charges for the year 2017 is SEK 1,742 million. Using Consumer Price Index to inflate revenue to the price level 2017, Figure 2 describes the development of revenue in real terms since 1991.

Figure 2: Revenue from track user charges, million SEK inflated to price level 2017 using Consumer Price Index.



Source: Information from Trafikverket

Table 5 summarises spending on railway infrastructure during the years 2014 – 2016. Total costs for maintenance and renewal in 2016 was SEK 8,022 million, while revenue from track user charges amounted to SEK 1,677 million that year. Cost recovery was therefore close to 21 percent of this total. Since renewal costs were SEK 2,192 million, charges represent 29 percent of maintenance costs.

2.3 The regulatory framework

Transportstyrelsen is Sweden's Regulator (SFS 2008:1300), also responsible for licensing and supervision of transport sector activities. The agency is an amalgamation of previously separate agencies for regulation and supervision of technical and traffic safety issues in the four modes of transport. This background on safety concerns permeates the Regulator's position relative to its assignment.

The Regulator is instructed to monitor the markets for railway services at large, including the provision of railway transport. This includes a responsibility for reviewing the efficiency of the final markets for tendered and commercial passenger services as well as freight services. The Regulator therefore publishes a bi-annual assessment of the situation in this respect. It is also given a responsibility for issues referring to "(r)equirements for infrastructure managers, traffic organisers and transport companies" (SFS 2008:1300, 3 §, task 3).

An ongoing audit addresses the design of track user charges. The regulator reviews current charges against the formulations in the Swedish Railway Act. No further information about the results of the review is currently available.

Table 5: Spending on railway investment, SEK million

	Year		
	2016	**2015**	**2014**
Tracks	2 352	2 326	2 939
-thereof renewal	*1 060*	*824*	*1 331*
Switches	502	425	459
-thereof renewal	*89*	*86*	*178*
Bridges	236	385	211
- thereof renewal	*182*	*339*	*140*
Tunnels	42	45	32
- thereof renewal	*34*	*31*	*-1*
Catenary	461	228	395
- thereof renewal	*417*	*187*	*348*
Other electrical installations	306	500	462
- thereof renewal	*79*	*276*	*231*
Signal and telecommunications installations	659	472	392
- thereof renewal	*346*	*195*	*165*
Other maintenance activities	654	722	590
- thereof renewal	*185*	*219*	*212*
Basic maintenance contracts	1 677	1 692	1 780
Fixed remuneration	1 115	1 129	1 192
Winter maintenance	314	324	326
Damage repairs	248	239	262
Maintenance management and support	208	176	167
Maintenance and renewal	7 096	6 972	7 427
-thereof renewal	*2 392*	*2 157*	*2 605*
Real Estate and Station Management	204	206	187
Other maintenance expenses	723	610	530
Total maintenance and renewal	**8 022**	**7 788**	**8 144**
Total investment	**10 616**	**12 166**	**10 133**

Source: Trafikverket Annual Report for 2016, Table 25 and Table 30.

Green Cargo is the rump of the incumbent operator in freight, still operating a major share of all freight train kilometres. The company made a formal complaint to Transportstyrelsen over the design of the track charges. The rate of the track charge described in Table 1 is levied per gross ton km based on the vehicle in the train with the highest axle load, i.e. *as if* all cars in the train had this weight per axle. After receiving a reply from Trafikverket (the IM), the regulator established that Trafikverket had not been able to demonstrate that this basis of the charge reflects the marginal costs for track wear. Trafikverket was therefore instructed to change the basis for levying the charge (TSJ 2017-2124). This is the only example of the regulator interfering with the structure of track user charges.

An additional component of the SERA Directive is the requirement to implement a Performance Scheme to incentivise railway operators and the infrastructure provider to improve the performance of the railway system, i.e. to reduce train delays. The IM administers the Swedish version of this scheme.

Nilsson (2016) shows that for three reasons, the system's current design does not provide the qualities that are necessary to deliver the incentives that are to be met by this type of mechanism. The first short-coming is that information about delays and their causes is incomplete. The most important deficiency occurs when a (primary) train delay has consequences for other trains in the system. Irrespective of the reason for the primary disturbance, subsequent trains may be re-routed and operated over a different path than was originally planned. The information collection process of today makes it impossible to register un-planned re-routing of services. While the annual number of disruptions of this nature may be low, passengers and freight customers may, on each occasion, be severely affected.

Secondly, today's system charges operators and the IM for <u>their own</u> delays but not for the knock-on consequences for <u>other</u> operators because of break-downs etc. of the first operator's trains. This is contrary to the purpose of the Performance Scheme, which is to inform the responsible party about the full implications of a primary disruption by way of making them pay a charge that reflects the externalities from the primary delay. The preferred way to provide incentives to reduce the risk for disturbances is therefore not implemented.

The third concern is related to the way in which the IM implements maintenance. All maintenance activities are tendered in competition. But delays emanating from infrastructure failures and the concomitant performance charges are not paid by the entrepreneur that is the immediate trigger of the failure but by the IM. This stops the appropriate signals from reaching the party that is best able to reduce the risk for recurrent failures.

Since the Nilsson (2016) report was submitted to the government, the IM has increased the level of the charges while the structure has not been changed.

3. Marginal cost estimates

The Swedish government has commissioned VTI[3] to review current knowledge of the social marginal costs for using the country's national infrastructure, i.e. roads, railways, airports and sea infrastructure. Based on research and reviews reported in several background papers, Nilsson and Johansson (2014) and Nilsson and Haraldsson (2016) summarise the results of this work, including also a comparison of marginal costs to year 2015 levels of taxes and charges. Nilsson et al (2017) provides a condensed version of these results for an international audience. While that paper includes all modes of transport, the subsequent text summarises the observations made relative to costs for the use of railway infrastructure. This background work is collectively referred to using the domestic acronym, SAMKOST.

Electrified traction accounts for 95 percent of the total number of train kilometres operated. For this reason, no attempt has been made to estimate the environmental costs from diesel engine emissions. As far as possible, results from SAMKOST are compared to recommendations made within the European Union reported as Ricardo-AEA (2014).

3.1 Noise[4]

The social cost of noise pertains to its direct impact on those working or living in an affected area as well as the long-term impact on health from noise exposure. Trivially, noise is not a problem where people do not reside while it may be a huge problem in densely populated conurbations.

The Impact Pathway Approach (IPA) provides the methodological framework for the analysis of both noise and other externalities. This bottom-up-approach was originally developed for estimating environmental benefits and costs.[5] Estimates account for the fact that inconvenience from noise is affected by the distance from, as well as barriers between, the source of noise and a building.

Since noise may affect the attraction and the sale value of properties, hedonic price approaches are often used for estimating the social costs of noise. The understanding is that values derived from hedonic pricing primarily relates to the direct effects from noise, while the long-term consequences for health may not be reflected in price differentials.

The Cnossos-EU model (Kephalopoulos et al, 2012) is used as a starting point for estimating emissions from different types of road vehicles. The SAMKOST project bases its use of this approach on information about number and type (heavy or light) of vehicles using some 100 000

[3] VTI, *Väg- och Transportforskningsinstitutet*, the Swedish National Road and Transport Research Institute in English, is a research institute owned by the government.
[4] This section is based on Swärdh & Genell (2016).
[5] IPA was developed as part of ExternE which is the acronym for "External Costs of Energy", a synonym for a series of projects starting from early 1990s till 2005. http://www.externe.info/externe_d7/

road sections within conurbations. To handle the consequences of different pathways taken by noise, distinctions are made between ground quality (hard or soft soil), settlement density and perpendicular distance of buildings from a road. Further, the conurbations are classified into four population density categories referring to the number of inhabitants per sq. km.

To assess the marginal noise costs for railways, detailed information about tracks and traffic is combined with information about population density in 250 m squares. This makes it possible to assess the number of individuals exposed at different distances from the source. Since the rail network is relatively small, and since it is split into some 250 track sections, the number of observations available for analysis is smaller than for roads.

The limited size of the network makes it straightforward to handle the specific feature of each rail section in the estimation of marginal costs. This is exemplified in Table 6, which provides examples of four sections, where the cost of one section (no. 401) is very high while the cost for using another (327) is very low. The difference stems from the fact that the first passes through a densely populated area, while traffic on the second inflicts damages on few people only.

Table 6: Examples of marginal costs for railway noise separated for section of track and type of vehicle, SEK per train km, price level 2014

Track section	Freight train (500 m, 90 km/h)	Passenger train (39 m, 120 km/h)
327	0.96	0.01
401	143.0	1.59
637	4.06	0.04
919	3.15	0.03
National average	4.22	0.05

Since different countries use different types of railway vehicles it is difficult to make a straightforward comparison of SAMKOST and Ricardo-AEA (2014) recommendations. An aggravating circumstance is also that track section values derive from actual number of exposed individuals rather than relying on broad categories, as in Ricardo-AEA (2014). The national average in Table 6 (SEK 4.22) is much higher than the corresponding value (SEK 0.61) in Ricardo-AEA (2014). At least a substantial part of the difference is due to a higher valuation function for rail noise disturbances used in SAMKOST, compared to the valuation function used in Ricardo-AEA (2014).

3.2 Accidents

Over the last 20 years, Sweden has had no train accidents with consequences for life or limb. The assessment of the expected accident risk in railway traffic therefore comprises two components; the impact of railway operations for collisions between road and rail vehicles at level crossings and the accident consequences for traffic variations for unprotected road users (pedestrians, cyclists, etc.).

The central issue for estimating marginal cost related to level crossing accidents is to establish how the expected accident cost changes when the number of trains changes. It may seem remarkable to link an accident risk to the vehicle in front of a train, not least since level crossing accidents usually depend on the driver of the road vehicle or the unprotected road user acting incorrectly. The train driver has probably not done anything wrong and has little opportunity to act relating to the accident itself. When a vehicle or unprotected road user is in front of a train, the train driver may reduce the impact but is (by definition, since observations of accidents are used) unable to avoid the collision.

The motive for linking risk to the railway vehicle derives from the legal literature that analyses how responsibilities and costs should be shared between the parties involved to minimise the risk of an accident at the lowest possible cost. The reason that the rail operator is to bear the cost of the accident is that the decision to operate a train service is a prerequisite for an accident to occur. Therefore, the operator can influence the risk by deciding how many times each crossing is passed.

The person using the road vehicle is facing the corresponding choice between driving or not driving. This is the reason for allocating the full accident consequences on both parties as a means for implementing appropriate incentives to take actions.

79 709 observations from the period 2000-2012 are used to identify the risk for accidents between trains and road vehicles, each observation linked to a certain level crossing a certain year. The model for accidents with unprotected road users is based on data from 2010-2012, a total of 17,913 observations.

Crossings between roads and railways with much traffic are typically grade separated. Accidents at level crossings therefore refer to roads where information about the number of vehicles is imprecise. This is the motive for using the classification of the road rather than the estimated number of road vehicles passing the intersection. Information about the number of passages of unprotected road users is even more scarce. This is therefore approximated by the number of people living within 2 km of the intersection.

Table 7 summarises the weighted average marginal cost per train passage for each combination of road type and protection. The cost difference between intersection types reflects both the differences in safety device, road type and train traffic between intersections.

Table 7: Accidents with road vehicles, weighted average margin cost (SEK) per train passage for different combinations of road type and safety device

	Full barrier	Half barrier	Light/sound	Unprotected
Major roads	1,11	1,58	17,65	
Local streets	0,47	0,62	4,22	3,85
Agricultural road	0,06	0,07	0,42	0,63

The marginal cost of accidents where unprotected road users are hit by a train is estimated at SEK 0.73 (5.02) per train passage or SEK 0.49 (3.32) per train kilometre. Numbers in parenthesis include suicides.

3.3 Infrastructure wear and tear[6]

Infrastructure agencies expend resources on both day-to-day maintenance and on renewals. The assessment of marginal costs seeks to understand how these activities are affected by traffic. One of the challenges for this analysis is to disentangle the quality deterioration because of time *per se* and the significance of usage for quality and maintenance to retain an acceptable road or track standard.

Maintenance

Johansson & Nilsson (2004) provides a first analysis of marginal costs for day-to-day railway maintenance costs. They use a standard regression approach to understand how the allocation of resources for maintenance of track sections is affected *inter alia* by traffic.

Sweden's national railway network is separated into some 250 track units. Table 8 summarises information about annual spending on day-to-day maintenance, about traffic as well as about technical qualities of each track unit.[7]

Table 8: Descriptive statistics for track sections for the 1999-2014 period (2819 obs.); day-to-day maintenance

Variable	Median	Mean	Std. Dev.	Min	Max
Maintenance cost, million SEK*	8,4	12,6	15,3	0	277,5
Hourly wage, SEK*	156	157	12	129	187
Iron and Steel, price index	113	100	31	52	141
Ton density (ton per track km)	5	8	9	0	66
Track length, km	56	69	51	4	291
Switch length, km	1	2	2	0	14
Snow, mm precipitation when temp. <0 C°	98	112	64	2	344
Dummy when tendered in competition	0	0,5	0,5	0	1

* Costs are inflated to the 2014 price level using the consumer price index (CPI).

With access to considerably more data than previous studies, Odolinski & Nilsson (2017) have derived new estimates of how track maintenance costs are affected by traffic variations; cf. ark values in this literature.

[6] This section is based on Nilsson et al. (2017).
[7] This section is based on Odolinski (2016b), Odolinski & Nilsson (2017) Smith et al. (2016) and Yarmukhamedov et al. (2016).

Tablee 9 shows that, while the static estimate of elasticity is 0.17, the addition of a dynamic component to the model increases the elasticity to 0.39. The dynamic aspect refers to a causal link from traffic not only on current but also on future activities; traffic variations one year is observed to have consequences also for maintenance in subsequent years. One reason may be that the response taken by the IM is insufficient in so far as the intervention "today", due to a traffic increase, makes it necessary to perform additional maintenance in the subsequent year(s) to get back to the equilibrium level of track quality. Both the static and the dynamic cost estimate are within the range of benchmark values in this literature.

Table 9: Elasticities and marginal costs per ton km for two models analysing day-to-day maintenance

Model	Method	Cost elasticity (std. err)	Marginal cost, SEK
Static	Fixed eff.	0.17 (0.04)	0.007
Dynamic	System GMM	0.39 (0.17)	0.012

Renewals

The seminal contribution to the analysis of renewal costs, i.e. the link between traffic and the timing of renewals, is Small et al (1987). That book summarises research to that date with respect to renewal of road infrastructure, but the analytical approach generalises across modes of transport. The point of departure is that asset quality (*Q*) deteriorates as a function of time (*t*) and traffic (*x*); $Q = f(t, x)$. When quality has deteriorated to some trigger value Q^L, a renewal activity is implemented at cost *C*. The present value cost (*PVC*) of an infinite series of renewals at this trigger value at constant time intervals $\bar{T}$ is given by eq. (1) where *r* represents the social discount rate.

$$PVC_{\bar{T}} = \frac{C}{(1-e^{-r\bar{T}})} \quad (1)$$

Networks comprise many track segments which are at different age/quality between their "birth" and "death", meaning that a specific segment at time $t*$ may have $\omega = (\bar{T} - t^*)$ years remaining until the next renewal activity at time $\bar{T}$. Since it is not *a priori* known which section that is to be upgraded, the estimation of *PVC* must account for two parts. The first is related to how "old" a section is when a change in traffic affects the timing of next renewal and the second to the present value of all subsequent renewals. Based on this logic, Andersson et al (2016) and Nilsson et al (2017) demonstrate that the expected marginal renewal costs of a change in railway and road traffic, respectively, relative to *ex ante* expectations can be characterised by eq. (2).

$$E\left[\frac{\delta PVC}{\delta q}\right] = f(C, r, \varepsilon, \mu, \omega) \quad (2)$$

Here, $\varepsilon = {}^{\delta X}/_{\delta q} * {}^{q}/_{x}$ is the deterioration elasticity, i.e. the impact on the first renewal date from a percentage change in traffic, and μ is the expected life length of the asset. Assuming that the survival of an asset can be handled using a Weibull model, a measure of this life expectancy is derived.

Yarmukhamedov et al. (2017) use a different estimation approach for assessing the marginal renewal cost in railways. The point of departure is that major renewals are rare, meaning that there are many observations of zero values; each year, most (road or track) sections are not renovated. The dataset is consequently censored in so far as the dependent variable has zero cost values at the same time as trains use that the track sections are represented in data. The zeros are true values, meaning that the infrastructure manager makes an actual decision on whether to make renewal or not. Following Andersson et al. (2012), a two-part, a Tobit and a Heckit model are estimated and the two-part model is found to be the preferred approach.

Using a survival approach, the life of a section of the asset is modelled as a sequence of zeroes and ones. The Weibull approach handles the many zeroes by translating the time between the ones into a number representing the life of this section.

Yarmukhamedov et al. (2017) analyse the link between traffic and timing of track renewals. Table 10 summarises some of the information used in the model estimation. Contrary to previous analyses of Swedish data, information is now available not only about sections of tracks between stations but also sections comprising station areas only. Another difference is that previous analyses have addressed only renewal of tracks, while the table shows that information is now available about costs for all spending on renewal – tracks, signalling, electricity and telecom – (first row) as well as for spending on tracks only (second row). The analysis establishes a causal link between traffic and track renewal as well as between traffic and power supply (catenary etc.) and signalling equipment.

Table 10: Descriptive statistics for track and station sections for the 1999-2014 period; renewal

	Track sections N = 2653		Station sections N = 317		|t-test|
	Mean	SD	Mean	SD	
Total reinvestment costs, million SEK*	7,4	26,7	8,2	20,4	0,05
Track reinvestment cost, million SEK*	4,0	20,8	1,2	3,5	2,39
Section length, km	72	52	26	25	15,79
Tonnage density (thousand gross tons per route)	7	8	13	12	12,12
Number of switches	85	69	190	161	21,06
Switch age, years	21	10	20	8	1,86
Rail weight, kg	51	5	51	3	2,07
Rail age, years	21	11	19	8	3,18
Number of trains, thousand	16	19	30	35	11,28

* Costs are inflated to the 2014 price level using the consumer price index (CPI).

Table 11 summarises the results of the analysis. The first row is based on analysing only costs for spending on tracks and superstructure while the second row also includes costs for renewal of electricity, signalling and telecommunication systems. While the elasticity is not much affected by this distinction, the estimate of marginal cost is. This is relevant since, with this approach, the marginal cost is calculated using eq. (3) where γ_{ik} is the cost elasticity for track section *i* with respect to tonnage density *(k)* and $\widehat{AC}$ is the predicted average renewal cost per gross ton km.

$$MC_{ik} = \gamma_{ik}\widehat{AC}_i \tag{3}$$

The marginal cost reported in Table 10 is higher than previous estimates; cf. RICARDO-ENEA (2014), table 48. Except for being based on a substantially longer time-period than the previous papers and comprising more track sections, the new results also verify that not only renewal of tracks-and-structures but also of electricity and signalling installations is affected by traffic.

Table 11: Marginal costs (SEK 2014 per ton km) for railway infrastructure renewal using two different cost definitions based on data for 1999-2014

	Elasticity	Marginal cost
Track superstructure reinvestment cost	0.55	0.015
Total reinvestment cost	0.53	0.034

4. Comparing 2015 track user charges and marginal costs for using railways

Table 12 summarises marginal costs for infrastructure use. In this, it should be acknowledged that noise is a local nuisance. Moreover, railway lines in parts of the network with much traffic and high speed have virtually no grade crossings, meaning that the marginal costs for accident risk primarily is concentrated to the secondary network. The risk therefore relates to the number of crossings when using a line. In the table, all costs have, however, been assessed for an average train service.

Congestion is another highly local phenomenon and primarily relates to the most used parts of the railway network. In railway traffic, it refers to the demand for departure slots that cannot be satisfied or that trains are forced to leave their origin at inferior departure times. No approach for estimating the significance of this externality is, however, currently available.

Table 12: Marginal costs for use of railway infrastructure, SEK 2015

		Passenger trains	***Freight trains***
Day-to-day maintenance	Per gross ton km	0,012	0,012
Reinvestment	Per gross ton km	0,034	0,034
Accidents, train-car	Per train km	0,92	0,92
Accidents; train-pedestrians (excl. suicide)	Per train km	0,49	0,49
Noise	Per train km	2,38	4,22
Congestion		+	+

The results reported in Table 12 are higher than marginal costs for railway maintenance in previous studies. As indicated above, this is explained by two things. (i) There seems to be a dynamic component of marginal costs for day-to-day maintenance, meaning that the marginal gross ton-km increases maintenance cost both "today" and "tomorrow", (ii) Not only reinvestment in tracks but also in signalling and electricity supply is at least partly driven by traffic. The table furthermore indicates that the only dimension in which there is a fact-based cost difference between freight and passenger trains refers to noise.

Table 13 summarises track user charges in 2015, excluding surcharges on diesel traction vehicles. The structure of the charges is basically the same as in 2017, as described in section 2 above. The level of charges is, however, almost 23 percent higher. This would – all else equal – reduce the gap between charges and cost. Since we do not have marginal cost estimates for 2017, it is not clear that everything else is equal.

Starting from the bottom, the peak charge is levied for using tracks in Stockholm, Göteborg and Malmö during morning and afternoon weekday peeks. Although little is known about the costs for congestion, a first proxy would be to assume these charges reflect congestion costs.

This presumption is however confounded by the charge per train kilometre which is imposed at three different levels. The low level refers to parts of the network that are seldom used and the high level applies to sections with much traffic. This would therefore signal another dimension of capacity shortage. Another complication when trying to account for the differentiation becomes apparent when observing that the train kilometre charge until 2014 was levied to account for accident costs.[8] While noise disturbances may be higher on highly used sections of the network, the opposite is true for accident costs.

The final component of the scheme is levied per gross ton km and was originally set to account for the wear and tear of vehicles on tracks. There is no analytical evidence of different wear and tear cost for passenger and freight trains. Instead, the differentiation originates in a previous administrative charge levied on passenger trains only; this component is now subsumed in this charging component. In comparison with the two components of costs for maintenance reported in the previous section, the level of the track use charge is well below current cost estimates.

Table 13: Track user charges in 2015, SEK

	Passenger trains	Freight trains
Track use charge; per gross ton km	0,014	0,005
Train charge, per train km; high	6,00	6,00
Medium	2,30	2,30
Base	1,90	1,90
Peak charge in three cities, per passage	416	416

For a passenger train weighing 300 ton and a freight train weighing 600 ton, Table 14 illustrates the implications of current levels of charging relative to costs. It is obvious that track user charges are well below marginal costs for using the railway network. Since there are some indications of scarcity in that not all trains are given slots at current levels of track user charges, the difference may even be larger than indicated by Table 14.

Table 14: Marginal costs and track user charge for a passenger and freight train, SEK/ train km

	Train weight, ton	Charge			Marginal cost
		Base	Medium	High	
Passenger	300	6,10	6,50	10,20	17,59
Freight	600	4,90	5,30	9,00	33,23

[8] The elimination of accidents as a basis for the charge was implemented in accordance with EU Directive 2012/34/EU. The directive states that charging for environmental or accident costs shall be allowed only if such charging is applied to road freight transport in accordance with Union law.

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