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Overview of the Implementation of Direct Costs in Europe

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Introductory Remarks

This paper provides an overview of the implementation of direct cost in Europe in line with Directive 2012/34 and Implementing Regulation 2015/909. It also provides in depth case studies for some countries as an appendix paper. A data collection was conducted to provide a quantitative background and proposed some explanations for differences. The data analysis presents direct costs across countries as used in the calculations but also from the point of view of railway undertakings by showing direct cost charges per train km for a range of representative trains. The data shows a wide range of implementations and resulting direct costs and direct cost charges across Europe.

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1. Purpose and Background of the Document

This paper provides a short, comprehensible and practice-oriented introduction to the calculation of the "cost that is directly incurred as a result of operating the train service" as set out in Article 31(3) of Directive 2012/34/EU. The Commission Implementing Regulation (EU) 2015/909[1] foresees a methodology to calculate direct cost based on the difference between the total underlying cost of providing railway services and a list of non-eligible ones. In addition, article 6 also allows using econometric and engineering methodologies to calculate direct cost. The paper presents these two methodologies.

This paper consolidates the insights of the following three previous papers published by IRG-Rail, and presents the developments that have taken place since their publishing.

1. An introduction to the calculation of direct cost in respect of implementing regulation 2015/909 (2016)[2]
2. Overview of charging practices for the minimum access package (MAP) in Europe[3] (2020)
3. Benchmark on Financing of Main Railway Infrastructure Managers in Selected European Countries[4] (2019)

Section 2 and 3 discuss the legal and economic background of direct cost. Section 4 compares how regulatory bodies (RB) review direct cost. Section 5 discusses the modelling of direct cost and methodologies used to do so. It also provides an overview of the used criteria to modulated direct cost across countries. Based on the insights of Section 5, Section 6 discusses the data collection that was conducted for the data analysis in Section 7. Section 8 concludes with some practical problems. An Annex paper presents country case studies for the methodology and calculation of direct cost of the main infrastructure managers (IMs) of countries across Europe and complements the paper.

2. Economic Background

According to recital (71) of Directive 2012/34/EU, "*Railway infrastructure is a natural monopoly and it is therefore necessary to provide infrastructure managers with incentives to reduce costs and to manage their infrastructure efficiently*"

Following the general definition provided by the literature[5], a natural monopoly is a market constellation, in which "*a single large firm serving the entire market would have a lower average*

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[1] Commission Implementing Regulation (EU) 2015/909 of 12 June 2015 on the modalities for the calculation of the cost that is directly incurred as a result of operating the train service, C/2015/3766, OJ L 148, 13.6.2015, p. 17–22 (BG, ES, CS, DA, DE, ET, EL, EN, FR, HR, IT, LV, LT, HU, MT, NL, PL, PT, RO, SK, SL, FI, SV), http://data.europa.eu/eli/reg_impl/2015/909/oj.

[2] https://irg-rail.eu/download/5/11/IRG-Rail168-GuidelinestothecalculationofdirectcostsinrespectofimplementingRegula.pdf

[3] https://irg-rail.eu/download/5/743/IRG-Rail2010-OverviewofChargingPracticesfortheMinimumAccessPackageinEurope.pdf

[4] https://www.irg-rail.eu/download/5/645/BenchmarkonFinancingofMainRailwayInfrastructureManagersinSelectedEuropeanCountri.pdf

[5] Braeutigam, R. R. (1989). Optimal policies for natural monopolies. *Handbook of industrial organization, 2, 1289-1346*.

cost than any smaller rival". Under a natural monopoly traditional market forces fail and do not lead to a supply and demand driven market optimum. Traditionally, natural monopolies have been associated with the existence of economies of scale throughout the relevant range of production, meaning that the absence of regulation is likely to lead to inefficiencies in terms of investments and price variations. Nonetheless, natural monopolies are nowadays explained by subadditivity in the cost function.

The existence of a natural monopoly justifies the need for regulation. In this regard, in order to solve these inefficiencies, in regulatory theory prices are set at marginal cost, which ensure the most efficient outcome of the market, meaning that social welfare, defined as consumer and producer surplus, is maximized.

More concretely, focussing on the rail sector, the White Paper of the Commission[6] addresses the need for a (so-called) community approach to infrastructure charging, identifying other potential objectives to be faced by regulation. This community approach seeks to "*improve the overall efficiency of the provision and use of European transport infrastructure, promote fair competition, safeguard the single market and enhance the sustainability of the transport system*". According to the White Paper, for a charging system to fulfil these objectives, all commercial modes of transport should follow the same principles and concepts, namely:

- Infrastructure charges should be based on the "user pays" principle, meaning that users of the infrastructure should be charged for the cost they impose on it.
- Charges should be directly related to the cost that users impose on the infrastructure and on others; besides the cost of direct use of the rail infrastructure this includes the environmental and other external impacts caused by the users.
- Charges should promote the efficient provision of infrastructure.

The White Paper then concludes that "*the only charging approach that satisfies these criteria is marginal social cost charging*". This approach implies charging users for both the internal and external cost that they impose at the point of use, in this case, on the rail infrastructure. Therefore, the White Paper does not only focus on maximising social welfare, but also on fostering efficient use by reflecting actual cost imposed on the infrastructure by its users. This second objective seeks that, by facing real cost, transport undertakings have clear incentives to adjust their operation by means of selecting vehicles, routes and logistics, or even modes of transport, that are less damaging to the infrastructure, less polluting and safer. Indeed, when analysing the rail sector, the White Paper claims that setting charges at marginal cost "*would send appropriate price signals to railway undertakings about the actual cost of each journey*".

The White Paper also identifies marginal cost charging as the way to achieve efficient transport use, since this goal "*is promoted when variable cost are reflected in the final prices faced by transport operators and users*". In turn, the efficient use of the infrastructure might have positive spinning effect in cost recovery. At this point, the White Paper quotes available evidence suggesting that "a consistent application of marginal social cost charging "*would in the current* [at the time the document was published] *circumstances lead to a significantly higher degree of infrastructure cost recovery from users in all inland transport modes in the EU than is currently the case*".

Finally, when the White Paper uses the term of marginal cost, "*it refers to short run marginal cost*". Therefore, cost of future increases in capacity (which are included in long run marginal cost) is not considered for charging purposes. These costs are difficult to measure and recovery through

[6] White Paper (COM (1998) 466) on Fair Payment for Infrastructure Use: A phased approach to a common transport infrastructure charging framework in the EU

charges "*would lead to significant inefficiencies in transport use during periods where capacity increases are not considered*".

3. Legal Background

Article 31(3) of Directive 2012/34/EU sets out the basic charging principle for calculating charges for the minimum access package:

> *"Without prejudice to paragraph 4 and 5 of this Article or to Article 32, the charges for the minimum access package and for access to infrastructure connecting service facilities shall be set at the* ***cost that is directly incurred as a result of operating the train service****."*

On 12 June 2015, the Commission adopted the implementing regulation (EU) 2015/909 on the modalities for the calculation of the cost that is directly incurred as a result of operating the train service. In this document, the Commission notably sets out the scope of cost that need to be considered and the suitable methodologies for the calculation of the cost that is directly incurred.

Article 3(1) presents the "difference" methodology and reads as follows:

> "*Direct cost on a network-wide basis shall be calculated as the difference between, on the one hand, the cost for providing the services of the minimum access package and for the access to the infrastructure connecting service facilities and, on the other hand, the non-eligible cost referred to in Article 4*[7]".

Moreover, Article 6 allows the infrastructure manager to calculate direct cost using other methodologies:

> "*By derogation to Article 3(1) and the first sentence of Article 5(1), the infrastructure manager may calculate direct unit cost by means of* ***robustly evidenced econometric or engineering cost modelling****, provided it can demonstrate to the regulatory body that the direct unit cost include only direct cost incurred by the operation of the train service and, in particular, do not include any of the cost referred to in Article 4."*

According to the Recast, "*The infrastructure charges referred to in paragraph 3 may include a charge which reflects the scarcity of capacity of the identifiable section of the infrastructure during periods of congestion*" (Article 31(4))[8]. In addition, article 31(5) states that "*The infrastructure charges referred to in paragraph 3 may be modified to take account of the cost of environmental effects caused by the operation of the train. Any such modification shall be differentiated according to the magnitude of the effect caused*". Article 32 provides exceptions to the basic charging principle for the minimum access package. In particular, Article 32(1) states that "*in order to obtain full recovery of the costs incurred by the infrastructure manager a Member State may, if the market can bear this, levy mark-ups on the basis of efficient, transparent and non-discriminatory principles, while guaranteeing optimal competitiveness of rail market segments*".

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[7] Article 4 of Implementing Regulation 2015-909 lists non-eligible costs.

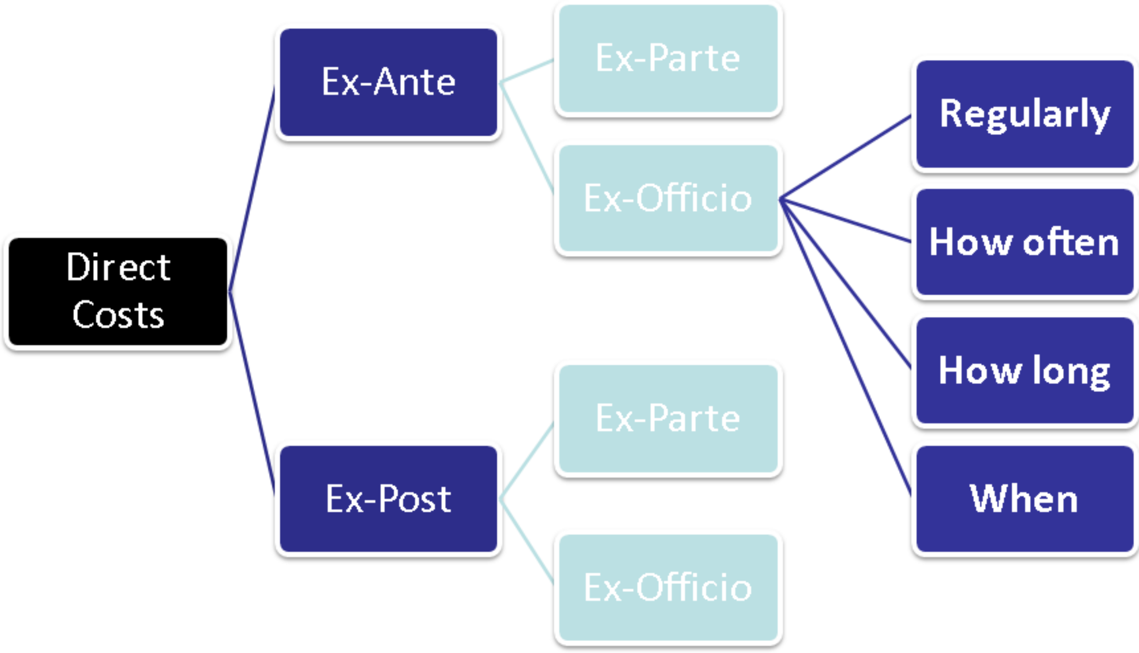
[8] For more information on capacity scarcity, see the IRG-Rail's position paper "Initial approach to capacity charging", 19-20 November 2014.

4. Review Process

Regulatory bodies (RBs) are required to review charges, the methodology and/or the level of charges[9]. The Directive 2012/34/EU does not define the review process and the competences of RBs are very different across countries. This section analyses the review process of direct cost across RBs and is based on the input of the RBs.

In many cases, the charges review process tends to be structured across three different dimensions illustrated by Figure 1 in a schematic way. The branching thereafter is the same for ex-ante and ex-post but it is only shown for ex-ante.

FIGURE 1: SCHEMATIC ILLUSTRATION OF REVIEW PROCESS OF RBS FOR DIRECT COSTS



Ex-Ante vs. Ex-Post
The first main cut off point is whether the RB has a competence to review direct cost charges before or after charges are applied. For instance, the IM might present his calculations to the RB that reviews these calculations before railway undertakings (RUs) actually pay them as charges, hence ex-ante. When RBs conduct a review after the implementation, this is considered as an ex-post review. For instance, the RB reviews the current direct cost charges after the network statement entered into force, while RUs already pay them to the IM or the network statements describing direct cost have already been published. Given that this is the main cut off point, the following two tables are split between these two different regimes.

Ex-Parte vs. Ex-Officio
A review can be triggered, ex-officio, out of the own accord of the RB or because it is mandated by the law (that could also imply that the IM starts the review process by handing in an application). For instance, the law may require a review of the direct cost methodology every five years. This could also imply a declaration of conformity by the IM or the RB involved. Furthermore, RUs or other market participants and entities have the possibility to request a review (Ex-Parte). There

9 For some regulatory bodies, the legal basis for this mission could be different from the transposition of the Directive 2001/14/EC or the Directive 2012/34/EU.

may also be differences between countries where parties may request an ex-parte review. We consider four possible answer categories. 1.) “IM” as the concerned IM of the review 2.) “Other IM” if another IM can request a review, 3.) “RU” for any RU able to request a review 4.) “Other” for any other entity, e.g. a local authority or an association representing RUs or other groups. Furthermore, all groups may have rights to appeal reviews or decisions.

Time dimension
In case the RB is doing an ex-officio review[10], the paper explores the timing of this review. This is why the table includes four columns to structure the time dimension of the ex-officio review:

- Regularly: A Yes/No column, if the review is done regularly or not
- How often: A column indicating the periodicity of the review, for instance, annually or every 5 years.
- How long: A column indicating the amount of time the RB has or usually needs for the review. This could for instance be a time period of 4 weeks or 2 months.
- When: A column indicating that some RBs conduct a review always at the same point in time with respect to the beginning of an upcoming timetable period as defined by Annex 7 (2) of the Directive 2012/34/EU. For instance, the review could take place 12 months before the start of the time table period, indicated by “X-12Month”.
- Extension possible: A Yes/No column, if the review can be extended if need be.[11]

There are no questions about the timing of the ex-parte reviews or complaints because Article 56 (9) already sets a maximum limit for these kind of complaints. The following chapters discuss each of the principles separately and present overview tables of the process. It is important to underscore that national specificities remain. Some RBs conduct regular reviews every year but conduct more in depth reviews every five years (for instance in Germany). If that is the case, the respective country might be shown twice to differentiate the minor and major review of the respective area.

[10] We focus on the time dimension of the ex-office review, because we expect this to be more structured as these would not depend on another party to kick of a review.
[11] We do not discuss the process who could request the extension and who could grant it, because this it out of the scope of the current analysis.

Table 1: Ex-Ante Review Process of Direct Costs by RBs

Country	Ex-Parte				Ex-Officio	If Ex-Officio applies				
	IM	Other IM	RU	Other		Regularly	How often	How long	When	Extension
Austria	✓	✗	✗	✗	✓	✓	For every timetable period			✓
Belgium	✓	✗	✗	✗	✓	✓	Every 5 years	3 months		✓
Czech Republic	✓	✓	✓	✓	✗	✗				
France	✗	✗	✗	✗	✓	✓	Every 3 years	2 months	X-12 months	✗
GB	✓	✗	✗	✗	✓	✓	Every 5 years	undetermined	X-3 years	
Germany	✓	✗	✓	✓	✓	✓	Annually	2 months	X- 14 months	✓
Germany	✓	✗	✓	✓	✓	✓	Every 5 years	undetermined	X- 3-4 years	✓
Greece					✓		At need			
Hungary	✓	✓	✓	✓	✓	✗				
Poland	✓	✓			✓	✓	Annually	90 days	X-9 months	✗
Romania	✗	✗	✗	✗	✓	✓	At need		At need	✓
Slovakia	✓	✓	✓	✓	✗	✗	At need	-	At need	
Spain	✗	✗	✗	✗	✓	✓	Annually	3 months	At need	✓
The Netherlands	✓	✗	✗	✗	✓	✓	Approval for max. 5 years	6 months	X- 24 months	✓

TABLE 2: EX-POST REVIEW PROCESS OF DIRECT COSTS BY RBS

Country	Ex-Parte				Ex-Officio	If Ex-Officio applies				
	IM	Other IM	RU	Other		Regularly	How often	How long	When	Extension
Austria	✓	✗	✓	✓	✓	✓	At need	At need		
Belgium	✓	✗	✓	✗	✓		At need			
CZ	✓	✓	✓	✓	✗	✗				
Finland			✓	✓	✓	✗	At need	-	At need	
France	✗	✗	✗	✗	✗	✗				
GB	✗	✗	✓	✗	✗	✗				
Germany	✓	✗	✓	✓	✓	✗	At need (on demand or own initiative)			✓
Greece					✓		At need			
Hungary	✓	✓	✓	✓	✓	✗				
Romania	✓	✗	✓	✓	✓	✓	At need		At need	
Latvia	✓	✗			✓	✓				
Lithuania	✗	✗	✓	✗	✓	✗	At need	Not specified	Not specified	✗
Luxembourg	✓	✗	✓	✓	✓	✗				
Norway	✓	✓	✓	✓	✓	✗	Not specified			✓
Poland			✓		✓	✗	At need	-	At need	✗
Slovakia	✓	✓			✓	✗				
Slovenia			✓		✓		At need, recommended 5 years		At need	✗
Spain	✓		✓	✓	✓	✗		Three months		✓
Sweden					✓	✗	Not specified	Not specified	Not specified	
The Netherlands	✗	✗	✓	✓	✓	✗				✗

We received information from 13 countries about the ex-ante review of direct cost (Table 1) and 20 countries provided information about their ex-post review (Table 2). Germany is listed twice because there are two different types of ex-ante reviews. Germany has a periodic review every five years at the beginning of its regulatory period and annually reviews direct cost for each time table period and the corresponding network statements. In Spain, under the Rail Act, charges are classified as taxed and, as such, tariffs shall be approved by the Spanish Budget Act. Therefore, even though the Spanish RB has the competence to ex-post review tariffs for direct cost, a potential decision by the RB modifying tariffs does not have a real impact, since it cannot modify a law

Looking at the ex-parte review for direct cost either ex-ante or ex-post, the affected IM can in many countries initiate or appeal a review. This is not the case for ex-ante in Romania, France and Spain. For ex-post, the IM cannot initiate it in GB, France, Lithuania, and The Netherlands. There are a few cases that another IM can initiate or appeal a review. There are countries in which another affected RU or another institution can initiate a review, but it is not very often the case and practices are quite diverse. In Austria for instance, authorized applicants (a company that is not usually part of the market but still ordering track paths)[12] can initiate an ex-post review of direct cost by the RB.

It seems that fewer countries have ex-ante ex-officio reviews for direct cost compared to ex-post ex-officio reviews (11 compared to 17 countries). The ex-ante reviews are conducted regularly in all countries but Hungary, Slovakia, and Czech Republic. This usually happens either annually or every three or five years. In some countries, they are also done at need. In contrast, ex-post reviews are not often conducted regularly (3 countries). In most countries ex-officio reviews are conducted upon request or it is not specified how often they are done (9 countries).

For ex-ante reviews, some countries have a predefined time period ranging from two months to six months and the reviews start around several months to almost two years before the beginning of the next timetable period. The countries that do bigger reviews (for instance GB and Germany) do not have a predefined time length and the reviews in Germany start several years before the respective timetable period.

Given that not many countries do regular ex-post reviews of direct cost, there are also few examples where the duration and the timing is predefined**.** For ex-ante reviews, six countries indicate that a time extension is possible. This is only the case for three countries for ex-post reviews.

5. Direct Cost Modelling

One of the main purposes of economic regulation is to ensure efficiency of cost of regulated activities (see Section 2). In this regard, Article 31 (3) of Directive 2012/34/EU establishes that

> "*Without prejudice to paragraph 4 or 5 of this Article or to Article 32, the charges for the minimum access package and for access to infrastructure connecting service facilities shall be set at the cost that is directly incurred as a result of operating the train service"*.

[12] See also EU Directive 2012/34 Article 3 (19) "applicant・ means a railway undertaking or an international grouping of railway undertakings or other persons or legal entities, such as competent authorities under Regulation (EC) No 1370/2007 and shippers, freight forwarders and combined transport operators, with a public-service or commercial interest in procuring infrastructure capacity;"

Mentioning the cost that is directly incurred as a result of operating the train service, or direct cost, raises the issue of how to properly identify these costs and which competences RBs have in relation to control them. In order to improve regulatory tasks, the same article mentioned above foresaw the adoption of modalities for the calculation of direct cost by the European Commission. The Implementing Regulation (EU) 2015/909 developed the framework for direct cost calculation, elaborating on different modalities to be used to adequately identify the cost that is directly incurred by operating the train service. This regulation introduces, in its recital (12), the idea of using the proxy of marginal cost for this purpose, since this price regulation ensures the optimum effective use of available infrastructure capacity, following the abovementioned recommendations set by the EC White Paper.

Economic theory understands this principle as the increase in cost that occurs due to an increase of one unit of traffic (for example in tonnes-km or in trains-km). As stated before, setting of marginal cost based prices is the optimum price regulation for rail infrastructure from a welfare point of view. It is equal to a price under competition in the market. However, given that calculation for marginal cost for the use of infrastructure is rather complex and implies a deep knowledge of the IM's cost structure and operation, the EC adopted the Implementing Regulation (EU) 2015/909, that approaches direct cost as the cost that is directly incurred by the operation of the train service. Article 3 (1) of this regulation defines direct cost as the difference between the total cost borne by the IM for the provision of the MAP and a list of non-eligible costs. According to recital (8), direct cost shall comprise only those cost that the IM "*…can objectively and robustly demonstrate that they are triggered directly by the operation of the train service*". Therefore, non-eligible costs, which are listed in Article 4, are cost borne by the IM that do not vary with the increase in traffic. However, as stated in recital (12), IMs may decide to use other proxies of marginal cost for the calculation of direct cost. IRG-Rail has also published guidelines to the calculation of direct costs in respect of Implementing Regulation (EU) 2015/909 in 2016.[13] However, regardless of the applied methodology (either subtraction or alternative approach), the IM shall base its estimations on a transparent, robust and objective model and demonstrate that costs are directly incurred by the operation of the train service according to article 3(4) of the Implementing Regulation (EU) 2015/909.

5.1. Methodology

Table 3 provides an overview on how countries have implemented the Implementing Regulation (EU) 2015/909. The first block of three columns show the three different methods for calculating the direct cost as highlighted in article 6. These methods are the following:

- Subtraction Method[14]
- Engineering cost modelling
- Econometric cost modelling

Costs estimates based on econometric approaches are used by some IMs, as in Finland, France, Netherlands, Norway and Sweden. Bottom-up engineering methods are also used. An engineering method is implemented in Austria[15]. French, Dutch, Swiss, Belgian and GB IMs already resort to such engineering and modelling calculations.

[13] https://www.irg-rail.eu/download/5/11/IRG-Rail168-GuidelinestothecalculationofdirectcostsinrespectofimplementingRegula.pdf
[14] Also known as deduction method
[15] Austria: The engineering cost model is mainly used for determined the part of the used caused depreciation of tracks and to allocate the direct costs to the different train categories.

In their review of charging principles, most RBs consider cost drivers. One could interpret the "cost directly incurred" as a short-run marginal cost that should include operating cost (*e.g.* signalling), maintenance cost (*e.g. wear and tear cost*), and renewal cost. As shown in the next block of three columns, these three categories are usually included for the calculation of direct cost.

The second last column shows, that GB considers efficient cost for the calculation of direct costs. Network Rail's direct costs reflect the RB's view on the appropriate efficiency challenge for the next control period, so are calculated to apply the "costs of efficient service provision" as per Article 3(2).

The last column indicates that all countries review the methodology of the calculation.

TABLE 3: OVERVIEW OF CALCULATION OF DIRECT COST ACROSS COUNTRIES

	Methodology to calculate direct			Costs considered to calculate of direct cost			Efficient cost[16] taken into account in calculation of direct cost	Review of direct cost methodology
	Subtraction methodology[17]	Engineering	Econometric	Operation	Maintenance	Renewal		
Austria	✓	✓	✗	✓	✓	✓	✗	✓
Belgium	✗	✓	✗	✓	✓	✗	✗	✓
Bulgaria	✗	✗	✗	✓	✓	✓	✗	✓
Croatia	✓			✓	✓	✗	✗	✓
Czech Republic	✓	✓	✗	✗	✓	✓	✗	✓
Denmark	✓	✗	✗	✓	✓	✓	✗	✓
Estonia	✗	✗	✓	✓	✓	✓	✗	✓
Finland	✓	✗	✓	✗	✓	✓	✗	✓
France	✗	✓	✓	✓	✓	✓	✗	✓
GB	✗	✓	✗	✗	✓	✓	✓	✓
Germany	✓	✓	✓	✓	✓	✓	✗	✓
Greece	✓	✗	✗	✓	✓	✗	✗	✓
Hungary	✗	✓	✓	✓	✓	✓	✗	✓
Latvia	✓	✗	✗	✓	✓	✓	✗	✓
Lithuania	✓	✗	✗	✓	✓	✓	✗	✓

[16] Efficient costs refer to direct costs calculated as described in Article 3 (2) of Commission Implementing Regulation n°2015/909.

[17] The difference methodology refers to the methodology presented in Commission Implementing Regulation n°2015/909.

	Methodology to calculate direct			Costs considered to calculate of direct cost			Efficient cost[16] taken into account in calculation of direct cost	Review of direct cost methodology
	Subtraction methodology[17]	Engineering	Econometric	Operation	Maintenance	Renewal		
Norway[18]	✗	✗	✓	✗	✓	✓	✗	✓
Poland	✓	✗	✗	✓	✓	✓	✗	✓
Portugal	✗	✗	✗	✓	✓	✗	✗	✓
Romania	✗[19]	✗	✗	✓	✓	✗	✗	✓
Slovakia	✓	✗	✗	✓	✓	✓	✗	✓
Slovenia	✗	✗	✓	✓	✓	✓	✗	✓
Spain	✓	✓	✗	✓	✓	✓	✗	✓
Sweden	✗	✗	✓	✓	✓	✓	✗	✓
The Netherlands	✓	✓	✓	✓	✓	✓	✗	✓

[18] Commission Implementing Regulation n°2015/909 is currently awaiting to be made part of the EEA-agreement and has therefore not been transposed into Norwegian law. It is therefore not yet applicable in Norway.

[19] In Romania, the IM uses a cost model to compute direct costs, but this model was developed under the former legal provisions. At present, the charging model is being revised by the IM and a new one is expected in the near future.

Within the Implementing Regulation, Article 3 (4) states that the IM may include in the calculation of its direct cost in particular the following cost categories:

a. **Costs of staff:** Costs needed for keeping open a particular stretch of line if an applicant requests to run a specific train service scheduled outside the regular opening hours of this line;
b. **Costs of points infrastructure:** the part of the cost including switches and crossings, that is exposed to wear and tear by the train service;
c. **Cost for electrical equipment:** the part of the cost of renewing and maintaining the overhead wire or the electrified third rail or both and the supporting overhead line equipment directly incurred as a result of operating the train service;
d. **Scheduling cost:** the cost of staff needed for preparing the allocation of train paths and the timetable to the extent that they are directly incurred as a result of operating the train service

In particular Article 3 (4) c in combination with Article 4 (1) k enables a separation of direct cost for electrical engines vs. non electrical engines. Therefore, an inclusion of the direct cost as specified in 3 (4) c may lead to differentiation of direct cost and, thus, differentiation of charges between those traffic types.

The following table shows which of the above categories are included in the direct cost of the main IMs of each country. 16 countries provided information for this table. One can see that cost of points infrastructure is considered in all countries that provided information. All but two countries also consider the cost for electrical equipment. All but four countries consider cost of staff and scheduling cost.

TABLE 4: OVERVIEW OF DIRECT COST CATEGORIES PROPOSED BY IMPLEMENTING REGULATION 2015/909 ARTICLE 3 (4)

	Direct cost categories proposed by Implementing Regulation 2015/909 Article 3 (4)			
	Cost of staff	**Costs of points infrastructure**	**Cost for electrical equipment**	**Scheduling cost**
Austria	✓	✓	✓	✓
Belgium	✓	✓	✓	✓
Czech Republic	✗	✓	✗	✓
Finland	✗	✓	✓	✗
France	✓	✓	✓	✗
GB	✓	✓	✓	✗
Germany	✓	✓	✗	✓
Hungary	✓	✓	✓	✓
Lithuania	✓	✓	✓	✓

	Direct cost categories proposed by Implementing Regulation 2015/909 Article 3 (4)			
	Cost of staff	Costs of points infrastructure	Cost for electrical equipment	Scheduling cost
Norway[20]	✗	✓	✓	✗
Poland	✓	✓	✓	✓
Romania	✓	✓	✓	✓
Slovakia	✓	✓	✓	✓
Spain	✓	✓	✓	✓
Sweden	✗	✓	✓	✗
The Netherlands	✓	✓	✓	✓

In The Netherlands, the direct cost for electrical engines and non-electrical engines are separated. The costs for electrical equipment are allocated to the MAP service 'tractive power supply'. The charge of this service consists of the transport cost of electricity and direct maintenance and renewal cost of the electric wire. The service only includes the use of the tractive power supply systems and not the supply of the electric power.

In Finland, the incremental cost that relates only to the electrical drive have been determined by using the subtraction methodology as described in Article 3 of the Implementing Regulation. According to this methodology, expert evaluation has been used to separate the cost directly incurred by traffic from the total network-wide incremental infrastructure cost that relate to electrical drive (electric distribution network). Finally, the cost has been divided by the gross tonne kilometres operated in rail traffic by electrical drive.

5.1.1. Subtraction Methodology

As mentioned before, the Implementing Regulation (EU) 2015/909 addresses direct cost primarily as the difference between total cost and non-eligible cost, therefore subtracting costs that do not vary with, or are directly triggered by the operation of the train, from the total cost of providing the services comprised in the MAP. According to art. 3 (1) of Implementing Regulation 2015/909, this methodology seems to be the initial approach for direct cost calculation, since it contains an extensive regulation of non-eligible cost.

Article 4 of Implementing Regulation (EU) 2015/909 includes an open list of non-eligible costs. This article tries to identify costs which are not variable with traffic and, thus, should not be included when calculating direct cost. The subtraction methodology, which seems straightforward, might be more complex and produce different outcomes depending on how the IM interprets the different cost listed in article 4 and if other non-eligible costs are also identified.

[20] Commission Implementing Regulation n°2015/909 is currently awaiting to be made part of the EEA-agreement and has therefore not been transposed into Norwegian law. It is therefore not yet applicable in Norway.

While some non-eligible costs in article 4 can be easily estimated by tracing them to the financial statements, such as letter (e) "financing costs", or letter (g) "costs of intangible assets"; others are more difficult to estimate, such as letter (a) "fixed costs relating to the provision of a stretch of line which the infrastructure manager must bear even in the absence of train movements", or letter (n) "depreciation which is not determined on the basis of real wear and tear of infrastructure due to the train service operation". In the latter cases, a proper estimation of the non-eligible cost implies a more complex approach by the IM, which might use some assumptions or ad-hoc studies and require further information other than that reflected in the financial accounts.

Therefore, direct cost calculation through subtraction methodology is subject to the interpretation and estimation by the IM of the different non-eligible costs and the results might vary considerably whether the IM uses an approach purely based on the information content in the financial statements, or whether it draws on other sources of information, including external information or technical studies.

According to recital (12) of Implementing Regulation (EU) 2015/909, "It is a well-established economic principle that user charges based on marginal cost ensure the optimum effective use of available infrastructure capacity. Hence, the infrastructure manager may decide to use the proxy of marginal cost for calculating its cost directly incurred as a result of operating the train service." The subtraction methodology can be used for entire cost centres or partly within cost centres to deduct costs within the centres.

The Implementing Regulation (EU) 2015/909 also foresees other methodologies for a higher degree of precision for the calculation of direct cost as a proxy for marginal cost. Indeed, Article 6 allows for modelling direct cost by means of a robust econometric or engineering methodology. These other approaches can be used combined with the subtraction method in order to obtain a more precise estimation of direct cost and are presented in the next two sub-sections.

5.1.2. Engineering Methodology

Engineering methodologies are based on engineering knowledge and techniques and sometimes are complemented by the information contained in cost accounting models. They blend bottom-up methods (to evaluate the physical relationship between the operation of train services and wear and tear of the infrastructure) and top-down cost allocation methods (to estimate future maintenance and renewal cost and allocate them to cost categories and reference objects). Operating cost other than maintenance may also be included in the calculation of direct cost provided that the infrastructure manager can transparently, robustly and objectively measure and demonstrate that these cost are directly incurred by the operation of the train service.

The technical college of the University of Ohio made an interesting description of the engineering- bottom-up methodology which can be used for calculating the direct cost. Bottom-up costing relies on detailed engineering analysis and calculation to determine an estimate. Process based cost estimation is the way to estimate cost based on the idea that the cost of all the processes that produced the desired finished product has a cost that can be associated with them. In this case the desired finished product represents the output which makes a rail infrastructure available and can comprise the operation, the maintenance, the renewal, the upscaling of the rail infrastructure which is altered by rail traffic. The bottom-up portion of this type of estimation can be seen when each process is estimated separately, for each sub-component and then all of the results are combined to produce one total estimate.

Traditionally, a bottom-up approach is a method that has the greatest advantage of being an accurate model that potentially calculates the cost of an efficient operator and that may be developed for each process. Because the accuracy of this model can be very good and every process is accounted for, this method can be very powerful. This process requires cost based estimation and then expertise in the sector to estimate the material and associated costs that must be used by each process model. Because it has to be scrutinized carefully, it does not afford quick way to estimate cost. The design must be very detailed as well in order for the input data to be precise. Another issue might be that the bottom up approach relies on estimates that may describe what should be instead of what actually happened. This has been pointed out by a report from the CERRE institute[21]. The reports also offers a comparison of the engineering and econometric estimates across some countries. This is what has been observed in Belgium. The Belgian IM has decided to use this method. Infrabel appointed an expert to analyse all the processes related to the operations and the maintenance of the rail infrastructure and to identify the relevant cost centres to be incorporated totally or partially in the direct cost. This process of analysis and evaluation was rather long and has required resources for both the regulator and the IM.

In Germany, direct cost is calculated from the total cost of the provision of the minimum access package. After the deduction of cost that are not relevant for the calculation of direct cost - as they obviously do not vary with the operation of trains (for example imputed cost, other operating income or other non-operating results) – relevant cost blocks with similar cost centres are identified. In Germany, the relevant cost blocks for the calculation of direct cost are timetabling, operation, maintenance, depreciation and cost of nodes. Those cost blocks are all – apart from the cost block depreciation - evaluated by expert engineers regarding their variability due to train operations. The experts define the degree of influence of a change in the amount of traffic on the respective cost in the cost blocks. Only the variable parts of the cost blocks are taken into consideration. Further, the experts evaluate which tasks and services are performed under the cost blocks to identify cost drivers: For each task or service decisive driving activities can be isolated (for example the number of track applications). With the help of these cost drivers, the costs are divided up between the market segments, resulting in the end in the total amount of direct cost per market segment. The cost block depreciation undergoes an econometric analysis. Using data based on observations of the German market, a regression analysis isolates the usage-dependent part of the depreciation. This is added to the direct cost per market segment calculated as described above.

In Great Britain direct costs that vary with traffic (maintenance and renewal cost) are estimated by the main IM (Network Rail) using engineering models. The main model – for directly incurred *track* costs – is known as the Vehicle Track Interaction Strategic Model (VTISM) and uses engineering expertise to simulate the wear-and-tear impacts of network use on track assets, for different types of traffic. This is used to develop a set of damage formulae (for horizontal and vertical forces) that relate track wear-and-tear to vehicle characteristics (weight, speed, suspension type etc.). Variable charges are then set to recover the efficient cost of the remedial

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[21] https://cerre.eu/wp-content/uploads/2020/06/180509_CERRE_TrackAccessCharges_OverallReport_final-1.pdf

maintenance and renewals activities that would be required to address the impact of running specific traffic types over the network[22]).

5.1.3. Econometric Methodology

Econometrics is a proven method blending mathematics, statistics, and economics which has the advantage of relying on actual data[23] to calculate the marginal cost of traffic. The econometric methodology enables to express cost as a function of traffic and other characteristics (e.g., characteristics of the network). Estimating this function yields the impact of traffic on cost, all other factors held equal (i.e. controlling for all other characteristics included in the estimation). Using the estimated impact of traffic on cost, it is then possible to deduct or calculate the marginal cost of traffic. Figure 3 summarizes the steps needed to calculate marginal cost using econometric methodologies.

To calculate marginal cost using econometric methods, the IM first needs to collect recent data on operations, maintenance and renewal cost, on traffic (expressed in terms of (gross) tonne-km or train-km and, if possible, disaggregated between traffic types), and on other characteristics (e.g. infrastructure characteristics as well as geographical or topological characteristics such as climate, population density or territory morphology) at the network section level (e.g. track or track segment level). Fixed and other non-eligible cost that are identifiable without econometric modelling may optionally be extracted from the cost base already in this phase. The datasets on cost, traffic and other characteristics should be merged into a single dataset to allow econometric estimation.

The data used should be available over a representative part of the network for a minimum of one year, although academics recommend using multiple years of data in order to obtain more precise results[24]. Indeed, multiple years of data enable the use of fixed effects estimation methods, which capture invariable unobserved infrastructure, managerial and climate effects that are expected not to change with respect to a base year. Longer term data also allow exploring the dynamic aspects of railway infrastructure operation and maintenance[25]. For this reason, IRG-Rail considers that it is important for IMs not to change the network section level over which they collect data over time, in order to enable the econometric analysis of data over a long time span to create a steady panel data set. If multiple years are used, the cost data should be adjusted in the national currency of a given year[26]. In any case, the sample size resulting from the segmentation of the network and the number of years considered should be large enough to enable the use of econometric analysis[27].

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[22] For other assets (e.g. signaling and civils), Network Rail uses expert judgement to estimate equivalent damage formulae. This provides an estimate of the direct costs imposes on these assets, as a result of operating trains on the network.
[23] Even if in France simulated data are used for estimating renewal costs.
[24] Andersson (2007) states that "(…) collecting data over time will give the research community and the infrastructure manager a possibility to provide better analyses".
[25] Andersson (2008) for instance shows that infrastructure operation and maintenance costs are reduced prior to a major renewal.
[26] See for instance Johansson and Nilsson (2004).
[27] On this issue, we refer the reader to the formulae described in Harris (1985).

For operational and/or maintenance cost, the annual cost at the track or track section level is assumed to vary with the characteristics of the infrastructure and the level of traffic that circulated during the year. In other words, annual operational and/or maintenance costs can be expressed as a function of the annual level of utilization to estimate the marginal effect of traffic on cost. A variety of functional forms have been used to econometrically estimate this cost function, including log-log (e.g., Marti et al. 2008), trans-log (e.g., Johansson and Nilsson 2004) and box-cox transformations (e.g., Gaudry and Quinet 2003)[28]. Log-log models provide a simple and transparent cost elasticity to traffic, which can be applied to the whole network. These models have the advantage of being easily conveyed and understood by all stakeholders. Trans-log models and box-cox transformations, while provide a more accurate fitness of the model, can be more difficult to apply and understand, as elasticities have to be computed and vary across network sections depending on the traffic levels. These models are useful to analyze non-linear relationships between traffic and wear and tear (and thus, marginal cost).

It should be noted that the estimation of renewal costs may differ from that of operational and maintenance costs, especially if the estimation is based on an annual relation between cost and traffic, as above. Indeed, in a given year, most assets will not be renewed, resulting in a large number of renewal costs equal to zero at the track or track section level. This is likely to lead to a low correlation between renewal cost and utilisation as a majority of observations with a positive annual traffic will be associated with a renewal cost of zero. In fact, the occurrence of renewal operations is more correlated to the cumulated traffic since the last renewal operation than to a given annual level of utilisation. Since IMs often lack data on such extended periods of time, academics have relied on more advanced methodologies that enable to circumvent these methodological issues and derive a marginal cost of renewal. These methods for instance include survival analyses[29] (e.g., Andersson et al. 2016) as well as censored and truncated models[30] (e.g., Andersson et al. 2012). Another way to address the issues related to the renewal cost is to one common cost function for operational, maintenance and renewal cost. In other words, renewal costs could be estimated together with operation and maintenance costs (as a bundle). Although this approach has sometimes been applied to circumvent the issues discussed above, Link (2015) underlines that the problems may only be solved "*if cross-sectional data for a sufficiently long time period is*

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[28] Including their variations, e.g. Cobb-Douglas is a simplified form of trans-log.

[29] In the context of the estimation of marginal costs of transports, Link (2015) explains the rationale behind the use of survival analysis: "[*i*]*t uses physical measurements of infrastructure damages or infrastructure condition to estimate a functional relationship, a so-called lifetime or duration function, between these measurements, infrastructure characteristics, traffic volume, climate information and other explanatory variables. The obtained damage-traffic relationships are evaluated in monetary terms by using costs for renewal work. The change in the lifetime as a consequence of traffic change affects the present value of future renewal costs and is thus the base for the marginal cost calculation. In contrast to econometric studies, duration approaches derive marginal costs based on renewal requirements independent of the actual spending for renewals.*"

[30] Andersson et al. (2012) explain the underlying differences between censored and truncated data as follows: *"[w]hen a relevant part of the population generating the data is unobserved, the data is said to be truncated. In this case, data on both the dependent and independent variables is not observed. For example, in a study of household income, the sample may only contain data for low-income households. Censored data is different. In this case, the dependent variable is not observable for some part of the population (though data on the independent variables are available). Again, using the study of household income as an example, above a certain threshold, income may only be recorded as being above that threshold (the actual income level is not recorded in the data set, perhaps for confidentiality reasons).*" The authors then argue that censored and truncated econometric models "*(…) have properties that make them suitable for estimation when data holds a large fraction of true zeros in the dependent variable*", which is the case for renewal data.

available". Unfortunately and as underlined above, the data needed for such estimations is often unavailable for such extended periods of time.

The final step of the analysis consists of determining the marginal cost and, optionally, deriving the elasticity of cost with respect to traffic, which yields the percentage of cost that vary with traffic. These estimates can be directly derived from the previously mentioned models, especially the log-log and the trans-log model.

The estimation of direct cost through an econometric model can be performed also to implement an efficiency/productivity analysis[31]. The objective of this type of analysis is to gauge the relative performance of decision making units, thus providing a benchmark for efficiency gains achievable by each unit. In the case at hand, the relative operation and/or maintenance performance can be assessed at different levels: at an international level (using data from foreign IMs) or within the country (for instance by comparing performance between different regions or maintenance centres). The quality of the econometric analysis strongly depends on the quality and quantity of data that are available. The models of efficiency analysis can be parametric (such as the stochastic frontier analysis) and non-parametric (such as the DEA). Models of stochastic frontier analysis of production and cost functions have already been used in regulated sectors and sometimes applied to cases with only one firm (but with different branches or business units considered)[32].

[31] The benchmark for this analysis is Farrell (1957). For an application to utilities industries, see Coelli and Lawrence (2006).
[32] See Coelli et al. (2013); and Cambini et al. (2014).

FIGURE 3. ESTIMATING MARGINAL COST USING ECONOMETRIC METHODOLOGIES

Step	Aim	Description
1 a	Collect data on costs	- Cost data on operation, maintenance and renewal costs - A preferred approach is to disaggregate these costs by type - Should be collected at the network section level, for at least one year - Identifiable fixed and non-eligible costs may be excluded from the cost base
1 b	Collect data on traffic	- Should be collected at the same observation unit as costs, for the same period - Usually expressed in tonne-km or train-km and a preferred approach is to collect data on each traffic type
1 c	Collect other data	- Collect data on infrastructure characteristics (*e.g.* number of tracks, type of rail, age of different components) at the same level as cost and traffic data - Additional data such as the different climates or regions can also be collected
2	Assemble datasets	- Data on costs, traffic and infrastructure characteristics should be merged into a single dataset to enable econometric estimations
3	Econometric estimation	- Estimate econometric models where the dependent variables are the types of costs, the variables of interest are the traffic types and control variables include for instance infrastructure characteristics, climate and region variables
4a	Derive elasticity	- From the results of the econometric model, it is possible to estimate the elasticity of costs to traffic - The elasticity represents the percentage of costs that vary with the level of traffic.
4b	Calculate marginal costs	- Marginal costs should then be calculated. They represent the costs per unit of traffic considered (*e.g.*, per train-km or (gross)tonne-km) - If an elasticity has already been derived then the marginal costs may be calculated as elasticities times average costs

In Finland, econometric modelling is performed for the cost excluding the incremental cost that relate to the electrical drive (electric distribution network). A dataset for years 2013-2016 is prepared for calculating the basic infrastructure charge, which describes the railway network, rail traffic operations and rail infrastructure management of the Finnish Transport Infrastructure Agency (FTIA) with the following data:

- features of the railway network by track section,
- annual kilometres operated by track section and
- annual expenses of rail infrastructure management (maintenance and replacement investments) allocated to track sections.

As a result, the cost incurred by kilometres operated in rail traffic (cents/gross tkm) are obtained for train traffic operated by diesel traction.

In Germany, the main IM conducts a regression analysis for the cost of depreciation. In addition to the train km of freight, PSO and Non-PSO traffic, some other infrastructure parameters (for instance number of switches and what kind of material) are used to model the cost per train km for depreciation. The IM then uses a three year moving average to avoid fluctuations. The methodology is explained in more detail in the network statement.[33]

In France, SNCF Réseau has developed an econometric model to estimate direct traffic-weighted costs. The calculation makes it possible to explain observed (maintenance) or modelled (renewal) expenditure by the technical characteristics of the infrastructure and by traffic. Note that the IM is in the process of reworking its econometric methodology, which will enable to take into account observed (and not modelled) renewal costs. These analyses provide an estimate of cost functions, from which traffic-weighted costs are derived.

In Sweden, Trafikverket does not have its own econometric model, but it relies on results from an independent government-run research institute.

In Norway, the IM, Bane NOR SF, has performed an econometric analysis on the basis of cost linked with corrective (remedying faults) and preventive maintenance of the infrastructure and traffic load measured in gross tonne-kilometres, as described in point 6.2.1.1.1 of Bane NOR's Network Statement for 2021. Bane NOR's econometric model aims to take into account that the lines used in the model have different technical designs in the form of the number of point switches, tunnels, speeds, etc. The model is logarithmic and operates with two products/services, passenger railway traffic and freight railway traffic. The estimation of the cost elasticities and thereby the marginal cost is carried out using the ordinary least squares method, often referred to as OLS in literature.

5.2. Criteria for Direct Cost Calculation and Modulation

Article 5 (1) of the Implementing Regulation 2015/909 states that the IM "*shall calculate average direct unit cost for the entire network*". Alternatively, the second paragraph of the same article allows IMs to calculate different direct cost for different parts of the networks if they can demonstrate to the RB that some parameters are significantly different for each part. Article 5 (2) allows the Member States to authorize the infrastructure managers to differentiate the direct cost based on different criteria and hence to differentiate direct cost charges across different train categories. This section analyses which criteria are used to calculate direct cost for direct train categories. Their use can be attributed to four different cases listed below:

- Applied
  The criterion is directly or at least partly used for the differentiation of direct cost. For instance, train mass can be used to adjust direct cost proportionally or to increase direct cost above a certain threshold.
- Discussed not applied
  The criterion is discussed in the network statement but the IM argues that it is not necessary or reasonable to use it. This might change in the future.

[33] https://fahrweg.dbnetze.com/resource/blob/3589412/c092f135a177d211b8545ca74f8df0b5/snb_2020_annex_6-1-data.pdf

- Discussed not practical
  The criterion is discussed in the network statement but the IM argues that he cannot use it or observe it.
- Not discussed
  There is no discussion about this criterion in the network statement of the IM.

The following chart compares the criteria used by each main IM of a country for both passenger services and for freight services. The heatmap below allows the reader to directly compare all criteria across in one country (horizontally) and a comparison of one criterion across countries (vertically) for freight and passenger services separately. The first graph below is related to freight services and the second one is related to passenger services.

In general, some additional criteria are applied for passenger services than for freight services. The number of criteria used varies between countries. Countries, like Austria, apply a relatively large number of criteria. In Austria, this is due to the use of the engineering model for allocating the cost to the different types on traffic.

FIGURE 2: HEATMAP OF DIRECT COST CRITERIA IN FREIGHT SERVICES

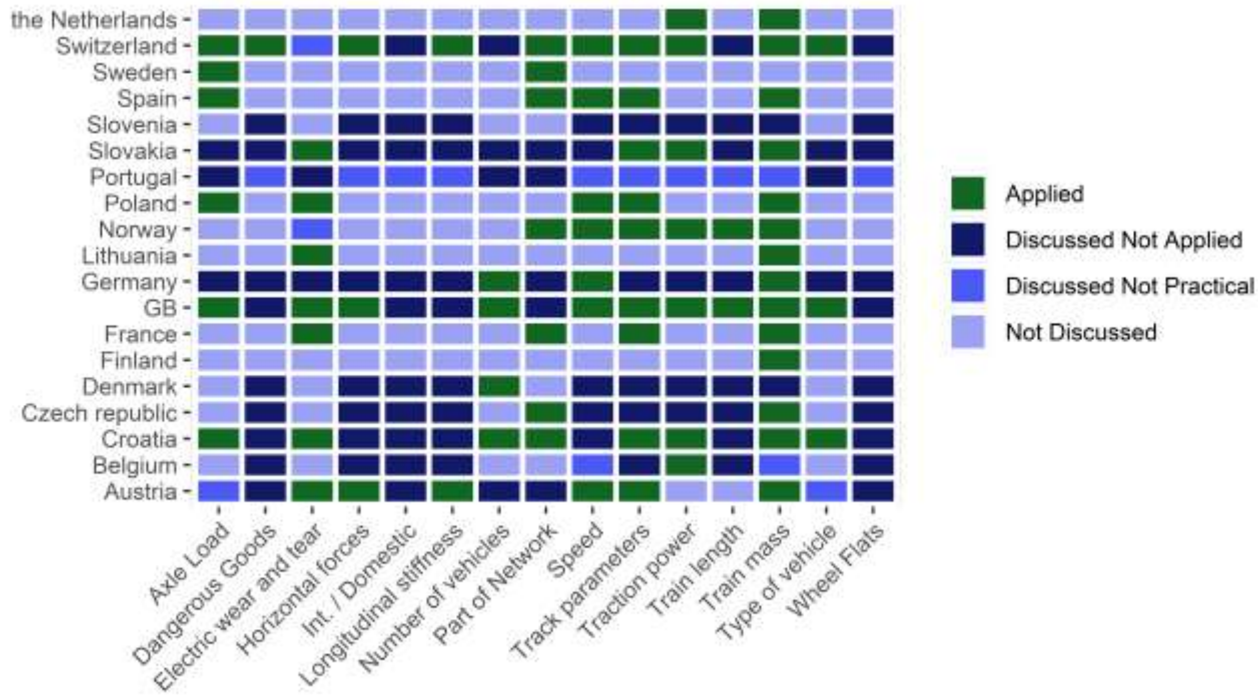
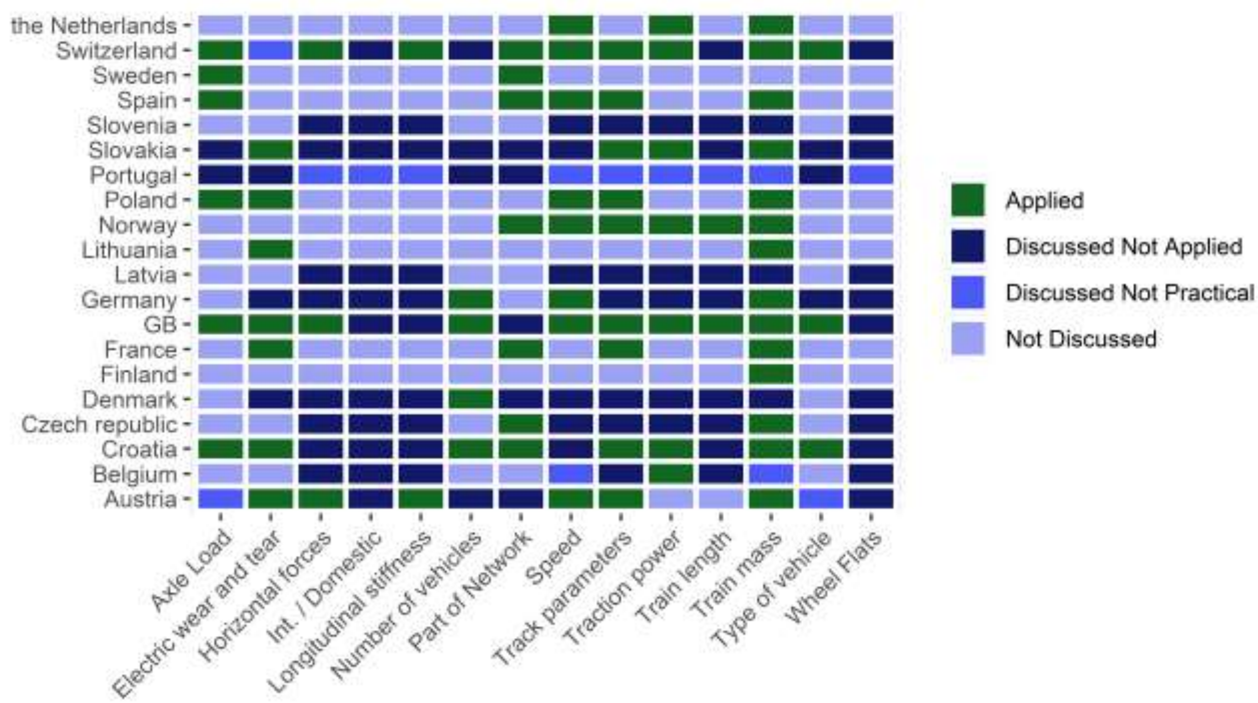


FIGURE 3: HEATMAP OF DIRECT COST CRITERIA IN PASSENGER SERVICES



The following section briefly discusses the different criteria and, if available, adds how they have been interpreted in some countries. The discussion is not split by freight and passenger services, because the criteria for both overlap but for one category and mostly the application of the criteria does not differ between the two services. In hindsight, one could aggregate the two heatmaps, but to show the point, heatmaps for freight and passenger services have been created.

Axle Load
In some countries, the IM differentiates the direct cost according to the axle load of the train wagons. The argument is that a higher axle load will strain the infrastructure more compared to lighter trains.

Dangerous Goods
One might argue that services with dangerous goods create higher direct cost, because they need more supervision. Currently this seems to be the case in Switzerland, and is discussed in some countries to be applied in the future.

Electric wear and tear
According to Article 5(2)(i) the IM may take into account consumed and measured electric power or the dynamics of pantographs or contact shoes as a parameter to charge for the wear and tear of the overhead wire or the electric rail. The German IM chose not to include this cost because the market segments, for which direct cost are calculated, do not differentiate according to the engine mode.

Horizontal forces
Horizontal forces refer to the forces of the vehicles to the rail, which interferes with the tracks. While they are usually smaller on straight lines, they occur in curves like tracks in the mountains and damage tracks.

International/ Domestic
Some IMs differentiate direct cost for domestic and international services based on the length and higher cost of services, some others do not.

Longitudinal stiffness
Longitudinal stiffness refers to the forces of the stiffness of vehicles on the tracks in curves, especially on mountain tracks with a narrow radius of tracks.

Number of vehicles
Article 5 (2)(a) of Implementing Regulation 2015/909 refers to “train length and/or number of vehicles in the train”. In the German TAC scheme, train km are used as a weighting factor for different direct cost clusters for which direct cost are calculated.

Part of Network
In Spain, the IM calculates separate direct cost for high speed and conventional networks as total cost and cost related to maintenance, renewals, etc., are significantly higher for high speed lines in terms of cost per train.km. Those lines also show differences in the type of trains, average speed and other parameters that justify its differentiation as a separate part of the network. The Czech IM uses 5 infrastructure categories with different coefficients for the calculation of direct cost.

In Sweden, the IM differentiates a direct cost charge based on the capacity utilisation of the lines. This is motivated by the fact that lines with higher capacity utilisation increases the cost for the IM to conduct maintenance of the infrastructure. However, this differentiation will be removed as of 2021.

Speed
Speed may play a role for the calculation of direct cost in two ways. Either by using the speed of the train or by using the track category (maximum speed) of network segments. The reasoning behind this criterion is that faster trains might produce a more intense wear and tear on the tracks compared to a slower train under similar conditions of mass and axel loads. This is the case in Germany. In Norway for instance, speed is included in the econometric model by using the track category (max speed).

Track parameters
Article 5(2) mentions track parameter, particularly radii, as a criterion to modulate direct cost. Other parameters might be related to speed, length, gauge, or interconnectivity of the track. Cost of wear and tear depends on the different tracks, like the radius of curves, type of track, maximum speed, and type of catenary. Therefore, direct cost may vary between the lines with varying parameters of the track.

The Austrian IM takes the different track parameters into account when calculating direct cost of the different train categories. In Norway, the track parameters are technical data for the track in the econometric model used by the Norwegian IM. These parameters are: Track length, bends, tunnels, point switches, speed and traction power.

Traction power
In Norway for instance, traction power is a technical input in the econometric model used by the IM.

Train length
In Norway train length plays a role for the calculation of direct cost indirectly through train mass, e.g longer trains have a higher train mass.

Train mass
The mass of the train can be one indicator that shows services that put more stress on the network. This is for instance the case in Germany, where trains with more than 3000 t are charged higher direct cost and train mass is used as a weighting factor to distribute cost across cost clusters. In Spain, direct cost related to tracks' maintenance and renewal are modulated between different segments according to technical criteria of the trains running the segments, being train mass on of the main parameter. In Finland, article 5 (2b) is not applied, but gross-tonne kilometres are used in accordance with article 5 (1). The Czech IM uses 22 weight categories with different coefficients to calculate direct cost.

Type of vehicle
Direct cost could depend on the type of vehicles that are used within a train. This could be different types of wagons or locomotives.

Wheel Flats
Wheel flats are flat spots on the rail wheel that could cause damage to the tracks and hence be considered for direct cost.

One can observe that the majority of the countries use the same criteria for passenger and freight services. Most of the countries use several criteria. Few countries (Portugal, Slovenia, and Latvia) do not use any criteria or are still in the process of discussing the criteria. Finally, a few countries only use one or two criteria (Denmark, Finland, Sweden, and Belgium). Speed, track parameters and train mass are most often used across countries.

6. Data Collection

IRG-Rail has collected data on direct cost for the Benchmark on Financing of Main Railway Infrastructure Managers in Selected European Countries in 2019. Since then, one would expect that countries might have refined their charging systems and that also their accounting systems might have improved to provide more data. Therefore, a new data collection for this paper focuses mostly on direct cost and related topic to complement the qualitative discussion from the previous sections. Some qualitative questions about the inclusion of subsidies or what kind of methods are used for the calculation of direct cost are also included.

To provide a general comparison, the paper looks at the development of train km (Trkm) and direct cost since 2017. To do this, the paper differentiates between ex ante and ex-post values. By this, we mean the following:

- Total Trkm (ex-ante): Total train kilometres within the network of the main IM that was used in the calculation of the direct cost. This data could have been estimated or predicted as the charges are calculated for an upcoming timetable period (for the future).

- Total Trkm (ex-post): Total train kilometres within the network of the main IM for concluded train movements in train km.

- Direct Cost (ex-ante): The calculated total direct cost, meaning the overall sum that is used ex-ante to estimate the direct cost charges (per unit). This does not refer to what is ex-post paid by RUs based on actual traffic; we refer to the overall amount of direct cost estimated or calculated before a new timetable period starts.

- Direct Cost (ex-post): The total revenue from direct cost charges. Hence, the overall amount of money RUs paid for in a defined and concluded timetable period.

Differences between ex-ante and ex-post data are expected as, in the first case, data is based on calculations and estimations by the IM, which are used for the determination of charges; while ex-post data refers to the actual data observed during the applicable year. These differences can be significant as ex-ante data can be based on historical information (for instance, last available year), thus implying a time gap between both periods, meaning that actual costs and traffic could differ from the initial estimation. Also, ex-post direct cost (as used in this paper) refers to revenue raised by the IM when charging for direct cost, which might not always equal actual direct cost.

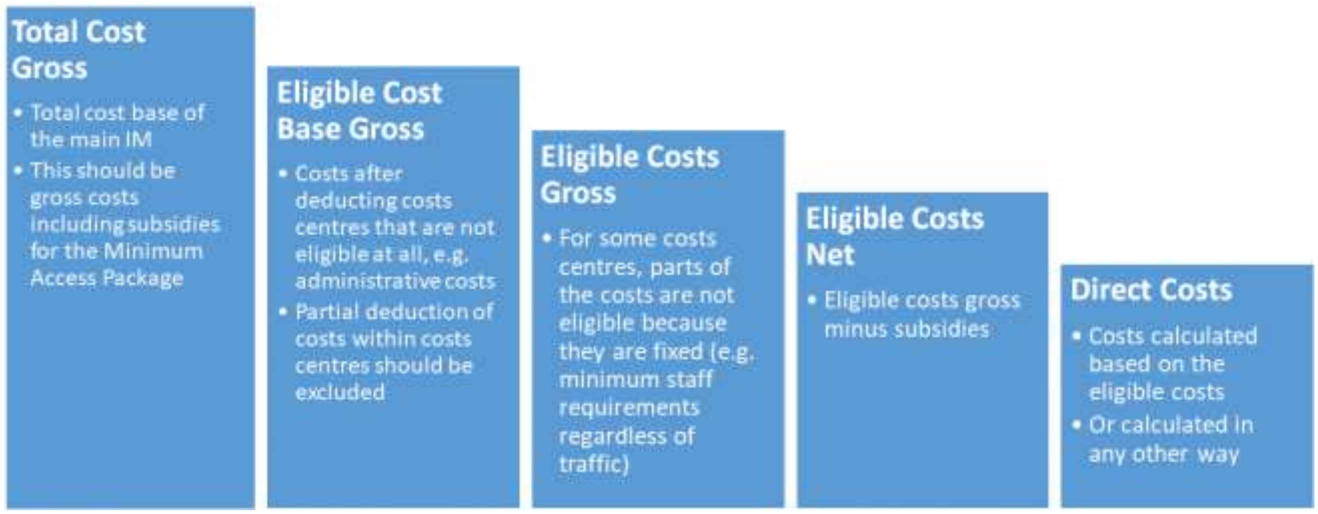
One could expect four different explanations for the difference between the ex-ante direct costs and the ex-post direct costs revenues.

1. Deviation between actual and predicted traffic
   As charges are calculated for future periods, many countries predict train km[34] for the respective year. If the resulted traffic is much lower / higher, the direct cost revenues are going to be lower / higher as well.
2. Change in demand structure
   Charges are calculated for certain clusters whose size is also predicted for the respective period. If traffic increase within a cluster with relatively high direct cost charges, ex-post direct cost revenues will increase
3. Reduced charges due to phasing-in
   Based on Article 9 of the Implementing Regulation 2015/909, some countries opted for the possibility to not directly charge the full amount of the calculated direct cost and instead gradually introduced direct costs charges at a lower value.
4. Change in system / methodology
   In some cases the entire system changed during the observed period, so that the historic data used for the estimation does not match anymore but still has to be used for the estimation.

As discussed in Section 5.1, IMs may use different approaches to calculate direct cost. Figure 1 shows one approach how direct cost can be derived starting from total cost. In some countries, IMs first exclude and deduct the cost centres that are entirely not eligible for the calculation of direct cost (see also Article 4 Implementing Regulation 909/2015). As a next step, the step is repeated within the cost centres to partially deduct fixed costs within cost centres (e.g. fixed staff to maintain a minimum level of service). From these eligible costs, direct cost can be derived using a cost elasticity. In some cases, subsidies are deducted from eligible cost (net) and other gross eligible costs are used to calculated direct cost.

[34] And or ton km or other necessary parameters used for the ex-ante calculation of direct cost charges. The data collection only collected data on predicted traffic

FIGURE 4: ILLUSTRATION OF TOTAL COST, ELIGIBLE COST AND DIRECT COST



More precisely, the following definitions were used in the data calculation.

I. **Total Cost**: The total gross cost of the main IM for the Minimum Access Package (MAP) that are assumed to be the baseline for the calculation of direct cost.
II. **Eligible Cost Base**: Cost remaining after deducting all fixed cost pools that are entirely deducted from total cost.
III. **Eligible Cost Gross**: Cost after deducting all non-eligible cost.
IV. **Eligible Cost Net**: Cost after deducting all non-eligible and subsidies
V. **Direct Costs**: Costs calculated based on eligible costs

It is to be acknowledged that this structure does not apply for all countries and that if data for all four categories is not available data should be provided at least for total cost and direct cost.

To illustrate Figure 4, consider the cost for train operations as shown in Table 5 and assume that total cost for train supervision is 1,000,000 € in a given year. Furthermore, this cost centre is supposed to be eligible and therefore nothing is to be deducted. Hence, the eligible cost base for train operations equals the total cost. Assume that the cost for train operations is only labour-based and that 60% of the staff has to be present at any time to guarantee the functioning and the safety of the network, the eligible cost is 400,000 € (as the 600,000 € are fixed cost). Assuming that the eligible cost is 40% elastic to a change in quantity, direct cost should be 160,000 €. If the cost elasticity is assumed to be 100% then direct cost would equal eligible cost. In this example no subsidies are included.

TABLE 5: HYPOTHETICAL EXAMPLE FOR THE CALCULATION OF DC WITHIN A COST CENTRE

Cost Centre	Total Cost	Eligible cost base	Eligible cost Gross	Eligible cost Net	Direct cost	Elasticity
Train Operation	1,000,000	1,000,000	400,000	400,000	160,000	40%

Figure 4 can also be used to help explaining differences across countries:

1. Size of MAP gross costs (first bar)
The starting point of the calculation might play an important role to be able to explain differences. However many different factors can play a role. One could consider the impact of efficiency and expect more efficient countries to have lower costs in general and hence lower direct costs. Other factors may include the general price level, the definition of what is part of the MAP or if the maintenance strategy is rather proactive or reactive.
2. Size of eligible cost base (difference first and second bar)
Some countries might deduct or omit some cost centres entirely from the calculation, which would result in a smaller eligible cost base and probably lower direct costs per train km.
3. Size of eligible costs (difference second and third bar)
As in the case of the complete deduction of cost centres, there could be differences in the share of costs deducted within cost centres, which would ultimately reduce direct costs per train km
4. Cost base of calculation (difference third and fourth bar)
The consideration of subsidies within the calculation can play a major role as it greatly increases the cost base of the calculation. One would expect countries that use gross costs (including subsidies) to have higher direct costs per train km than countries using net costs (excluding subsidies).
5. Cost modelling choice / elasticity (fifth bar)
In a perfect world, both engineering or econometric models could return the same direct costs and generally result in direct cost elasticity of less than 100%.[35] A pure subtraction approach would imply a direct cost elasticity of 100% as eligible costs are just divided by traffic. Hence, one expects countries with subtraction approaches to have higher direct costs per train km. One would have to explore differences for countries using engineering and econometric models.
6. Direct cost clustering & distribution of clusters
Direct cost can be attributed to different clusters and some clusters might cover relatively high shares of direct costs compared to others. This can depend on many factors within the modelling process. Anecdotally freight segments (in particular very heavy trains) are assumed to induce higher direct costs. Hence, one would expect countries with high shares of (very heavy) freight traffic to have higher direct costs per train km.
7. Network intensity / Size
The degree of capacity utilisation might play a role if the direct cost function was degressive or progressive at the level of traffic[36]. In countries with low capacity utilisation, additional traffic would not create a lot of direct costs it the cost function was progressive at this level. With increasing traffic and a higher degree of capacity utilisation, the cost function could switch to be degressive,

[35] The CERRE TAC Report shows elasticities much lower than 100% for wear and tear costs and only 15% for planning an operation costs.
https://cerre.eu/wp-content/uploads/2020/06/180509_CERRE_TrackAccessCharges_OverallReport_final-1.pdf
[36] Section 5.1.3 discusses function from like a trans-log model that would be able to model such a behavior.

resulting in a lower direct cost elasticity and less direct costs per train km. So in both cases direct cost per train km might be lower.

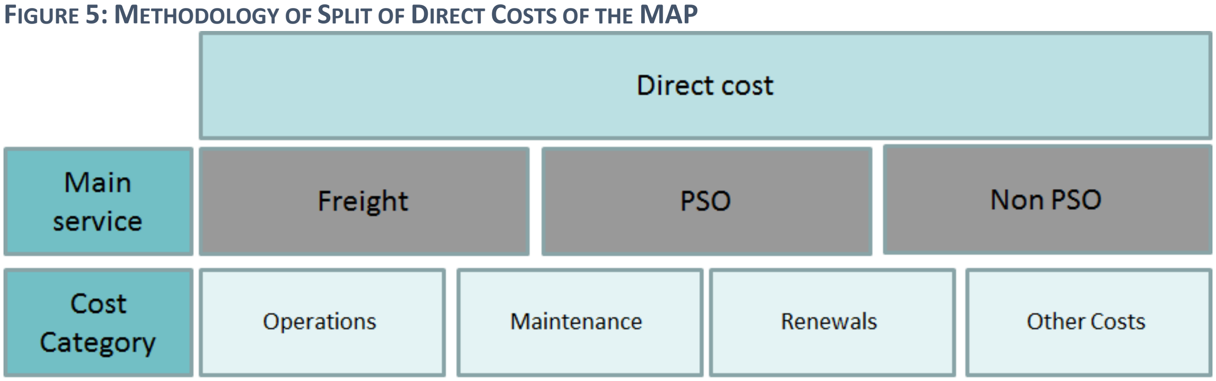
One could also consider the impact of efficiency and expect more efficient countries to have lower costs in general and hence lower direct costs. However, no data was collected about efficiency and IRG Rail is not aware of any good public study to rank countries according to their cost efficiency in the rail sector.

Furthermore, data was collected to look at direct cost by main service[37] (freight, PSO, and non-PSO) and also differentiated by cost categories:

- Operations
- Maintenance
- Renewals
- Other

Figure 5 illustrates our approach. Optimally, one would like to differentiate cost by main service and cost category if data would have allowed for it. From our experience from the benchmark on financing of main IMs carried out in 2020, not many countries are able to provide data split by main service and cost category.

Figure 5: Methodology of Split of Direct Costs of the MAP



Lastly, this paper tries to estimate ranges of direct cost charges for certain kinds of representative trains (see Table 6), since many countries not only charge per train km but also modify the charges based on weight or the type of engine used. This information is not focussed on costs, but rather on actual prices as published by IMs in their Network Statements. This can provide a more realistic picture than just comparing direct cost charges per train km, given that direct cost charges might, in some cases, not equal unit direct cost due to other circumstances (such as further subsidies, phasing-in periods of new model estimations or other practical or legal reasons). In order to this, the following twelve different representative trains for which the minimum and maximum direct cost charge per train km were set out.

[37] In reference to EU Directive 2012/34 Article 32 (1), we define main services as the three segments that IMs shall at least consider for their list of market segments: freight services, passenger services within the framework of a public service contract and other passenger services.

TABLE 6: LIST OF REPRESENTATIVE TRAINS

Type of service	Specific	Engine	Speed	Weight	Double Train
Freight	-	Electric	-	1000t	
Freight	-	Diesel	-	1000t	
Freight	-	Electric	-	3000t	
Freight	-	Diesel	-	3000t	
Passenger	non-long distance (PSO)	Electric	-	600t	Yes
Passenger	non-long distance (PSO)	Diesel	-	600t	Yes
Passenger	non-long distance (PSO)	Electric	-	300t	No
Passenger	non-long distance (PSO)	Diesel	-	300t	No
Passenger	long distance (Non-PSO)	-	Non High Speed	800t	Yes
Passenger	long distance (Non-PSO)	-	Non High Speed	400t	No
Passenger	long distance (Non-PSO)	-	High Speed	800t	Yes
Passenger	long distance (Non-PSO)	-	High Speed	400t	No

Freight and non-long distance (PS) trains are differentiated by the type of engine (electric vs. diesel). Different weight values are provided for each representative train. Besides the different main service categories, the type of engine and the weight are expected to have the biggest impact. Using ranges makes it possible to compare countries even if the respective system are more or less differentiated and even if charges are not only calculated based using €/Trkm as a unit.

7. Data Analysis

For this chapter, 21 countries provided data using an excel template based on Section 6. Not all countries were able to provide all the data. It seems that it was more difficult to provide the more detailed data on the different cost categories and only a few countries were able to provide data on eligible cost as requested according to Figure 4. Therefore, the paper will not analyse this data in more detail. In the future, the methodology could be revisited and clarified to allow more countries to provide data. In some cases, concerns of confidentiality also played a role. All non-Euro data was converted using Eurostat exchange rate data.[38] The following table lists the respective countries, the country code, RBs, and Main IMs. To discuss the data and results, the paper always uses the country name or code that refers to the respective RB and main IM.

TABLE 7: COUNTRIES, RBS, AND MAIN IMS PROVIDING DATA FOR THE PAPER

Country	Code	Regulatory Body	Main IM
Austria	AT	Schienen-Control GmbH	OEBB-Infrastruktur AG
Belgium	BE	Regulatory Body for Railway Transport and for Brussels Airport Operations	Infrabel
Bulgaria	BG	RAILWAY ADMINISTRATION EXECUTIVE AGENCY (RAEA)	STATE ENTERPRISE "NATIONAL RAILWAY INFRASTRUCTURE COMPANY"
Croatia	HR	Hakom	HŽ Infrastuktura d.o.o. (HŽ infrastructure ltd)
Czech Republic	CZ	Úřad pro přístup k dopravní infrastruktuře (Transport Infrastructure Access Authority)	Správa železnic, státní organizace (Railway Administration, a state organization)
Finland	FI	Finnish Rail Regulatory Body	Finnish Transport Infrastructure Agency
France	FR	ART	SNCF Réseau
Germany	DE	Bundesnetzagentur	DB Netz AG
Great Britain	GB	Office of Rail and Road	Network Rail
Hungary	HU	Rail Regulatory Body	MÁV Zrt.
Latvia	LV	State Railway Administration of the Republic of Latvia	SJSC "Latvijas dzelzceļš"
Lithuania	LT	Communications Regulatory Authority of the Republic of Lithuania	AB "LTG Infra"
Netherlands	NL	ACM	ProRail
Norway	NO	Norwegian Railway Authority	Bane NOR SF
Poland	PL	Polish Office of Railway Transport	PKP Polskie Linie Kolejowe S.A.
Portugal[39]	PT	AMT - Autoridade da Mobilidade e dos Transportes	IP - Infraestruturas de Portugal, S.A.

[38] ECU/EUR exchange rates versus national currencies [TEC0003]
https://ec.europa.eu/eurostat/databrowser/product/page/TEC00033
[39] Portugal could only provide data for 2020 because direct cost charges have only been introduced since then. This plays a role for some graphs in Section 7.1., 7.2. and 7.3 where other countries provided data for 2019."

Romania	RO	National Railway Supervision Council	Romanian National Railway Company "CFR" SA
Slovakia	SK	Transport Authority	ŽSR
Slovenia	SI	AKOS RS	SŽ-Infrastruktura, d.o.o.
Spain	ES	CNMC	ADIF
Sweden	SE	Transportstyrelsen	Trafikverket

7.1. Total Direct Cost

Section 6 introduced a differentiation between ex-ante and ex-post values, to discover differences in ex-ante calculated direct costs and ex-post direct cost charges revenues. Surprisingly, only 10 countries were able to provide both values as shown in Figure 6 and Figure 7. Each figure shows the percentage difference between the ex-ante and the ex-post value. Meaning that a negative / positive value indicates that the ex-ante value was higher / lower than the ex-post value.

FIGURE 6: COMPARISON OF EX-ANTE AND EX-POST DIRECT COSTS ACROSS COUNTRIES OVER TIME

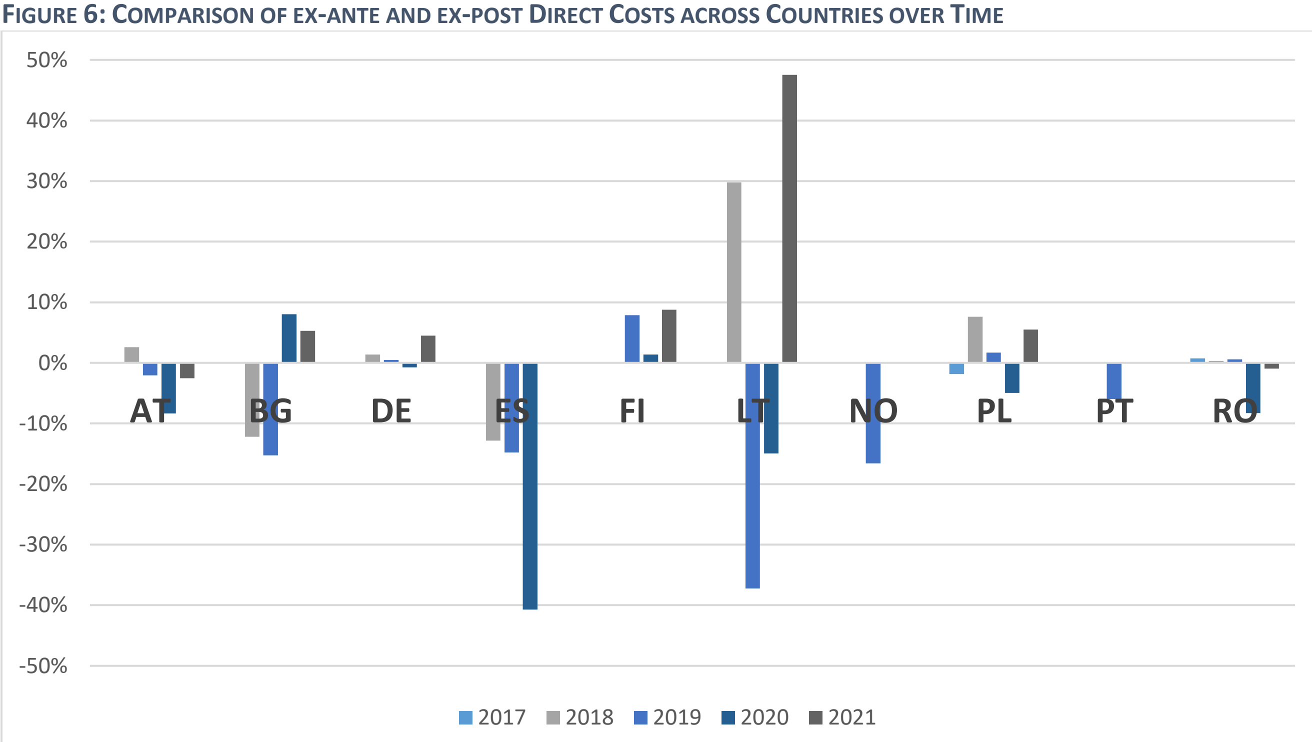
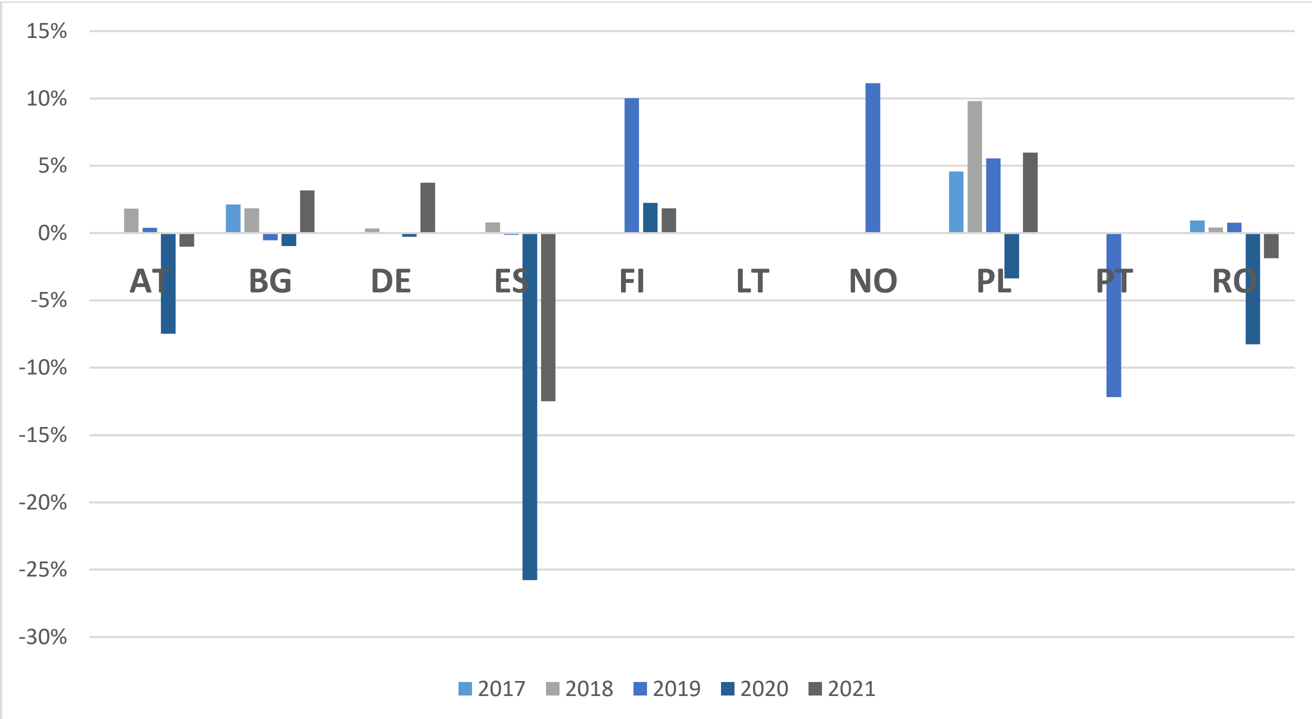


FIGURE 7: COMPARISON OF EX-ANTE AND EX-POST TRKM ACROSS COUNTRIES OVER TIME



Looking at the differences between ex-ante and ex-post direct costs in Figure 6, the difference remains below 10% for most countries, except for Bulgaria, Spain, Lithuania, and Norway. When examining both figures, there seems to be a correlation between the differences in direct costs and train km and indeed the correlation coefficient is roughly 0.5.

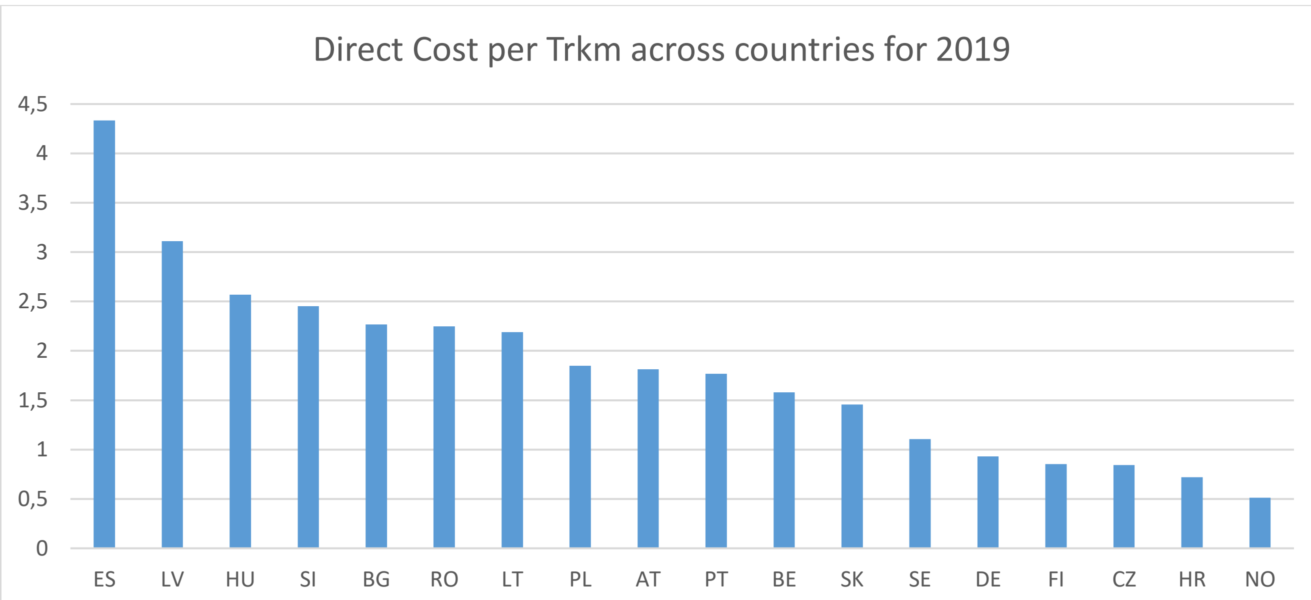
In Austria the differences reflect on the one hand the difference between the traffic forecast and the actual traffic as well on the other hand the reduction of charges due to the decisions of the RB taken until end 2020. Hence, it seems that the deviations between ex-ante and ex-post direct cost calculations and revenues can be attributed to a deviation between actual and predicted traffic (the first explanation provided in Section 6 for this kind of data). In Bulgaria, the differences can also be attributed to some deviations between actual and predicted traffic and a time lag of using historical data for the calculation of direct costs.

In Norway, a phasing-in plan was introduced by the IM and RUs did not pay the full direct cost charges, so that revenues were lower even though demand increased, which was the third suggested explanation at the beginning of Section 6.

Lithuania is an example of a changed system (the fourth explanation at the beginning of Section 6. These changes were effected due to changes in direct costs allocation principles applicable by the IM. These amendments were made according to the implementation of the Commission Implementing Regulation (EU) 2015/909. Lithuania did not provide values for ex-ante train km because the calculation is based on tonne km.

Due to the fact that not all countries were able to provide both ex-ante and ex-post direct cost and train km, the provided data was consolidated into one indicator that consists of the ex-ante value if available and the ex-post value in case no ex-post value was available. This approach has been chosen because ex-ante values are the ones that were used for the calculation of direct cost charges. Ex-post values rather represent the revenues from direct cost charges. Reversing the order of the calculation of the indicator does not change the results much as shown in the previous two figures.[40] This indicator is used for Figure 8 (and in all following figures on direct costs) and shows the direct cost per train km across countries for 2019 in descending order.

FIGURE 8: DIRECT COST PER TRKM ACROSS COUNTRIES FOR 2019



Based on these 18 countries the weighted average is 1.54 € / Trkm. Spain seems to be an outlier and has the highest direct cost per train km, which is considerably higher than the second country and way above the average. The Spanish RB (CNMC) has announced in several decisions that the methodology used by the IM fails to properly identify direct costs as it probably does not deduct all non-eligible costs which are not variable with traffic. The RB is currently reviewing the methodology in-depth.

For some countries the relative high importance of freight traffic might explain the overall higher direct cost charges. In Latvia, Slovenia and Lithuania direct cost per train km are relatively high because the network is used by a lot of heavy freight traffic. Figure 12 shows the direct cost per train km for freight. These costs are rather high for Latvia and Lithuania and Figure 16 shows that the share of freight is high both for direct costs and traffic. For both countries and Slovenia, one can see further evidence on this in Figure 21, which shows the direct cost charges for freight compared to passenger services. This line of reasoning applies to a lesser degree

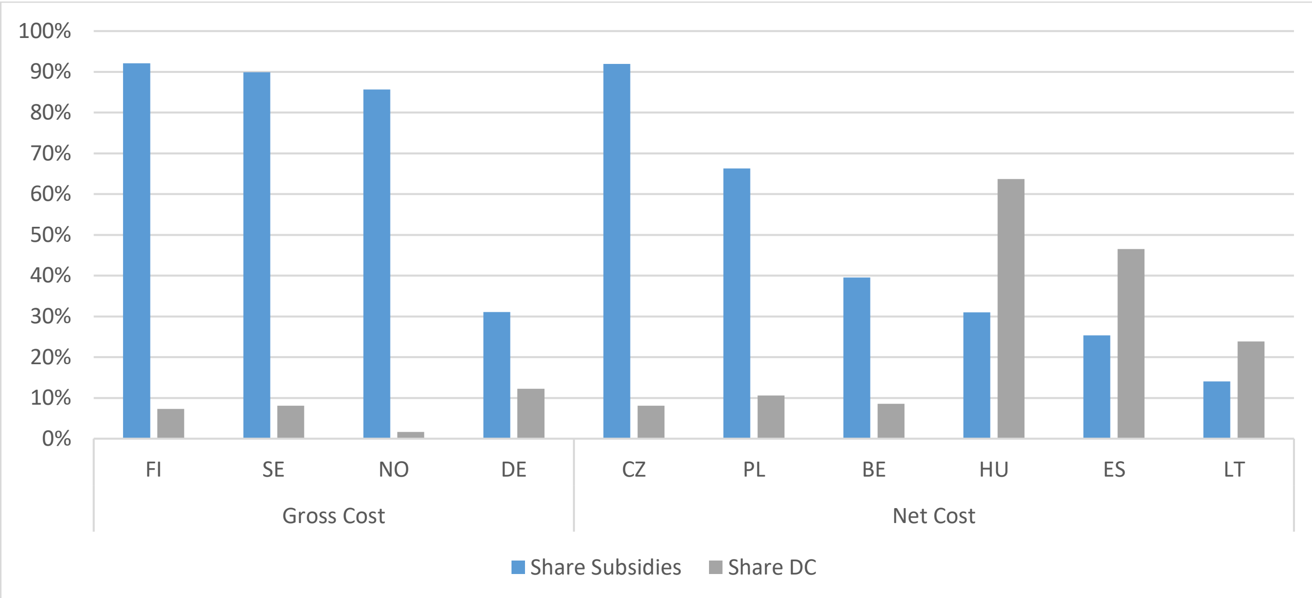
[40] The following countries only provided ex-post values for direct costs: Belgium, Croatia, Czech Republic, France, Slovakia, Slovenia, and Sweden.

for Austria and Poland as well. In Hungary, direct cost charges are calculated based on gross tonne km and train km, so this might play a role that charges appear rather high on a per train km comparison.

There are also some countries with overall charges that are lower than 1€ / Trkm. In Norway, the reason could be that the system in 2019 only considers maintenance for direct costs (see Table 10) and then an econometric model is used. Croatia uses net costs as the cost base and does not include renewals at all and has low maintenance costs, which might a reason for the rather low direct costs. Furthermore, the methodology does not only rely on the subtraction method and the capacity utilisation is very low. In Germany the range of direct cost charges is comparatively small compared to other countries. This is shown in Section 7.4 and Figure 20. Furthermore, PSO services have a rather low direct cost charge of around 70 cents per train km and constitute almost two third of the traffic, whereas the most expensive segment of heavy trains only accounts for a small percentage of the traffic. One might have expected higher direct costs per train km, because of the usage of gross costs. However, Germany uses subtraction in all costs centres to completely or partially deduct non-eligible cost as part of the engineering approaches and uses an econometric approach for renewals that imply relatively low cost elasticities. At the degree of capacity utilisation is rather high so costs are distributed across a high volume of traffic. In the Czech Republic the share of subsidies is above 90% (see Figure 9) and net costs are used for the calculation of direct costs, which could explain the low direct costs per train km. In Sweden with direct cost per train km are a bit higher than 1 € / Trkm and the Swedish IM believes that the econometric modelling, that its direct costs estimates are based on, results in rather low direct cost estimates compared to using a subtraction method. The methods used may also yield lower estimates of elasticities compared with other methods, which has also been suggested by a CERRE study of 2018.

Section 6 considered the impact of subsidies on the calculation of direct cost and therefore data on the amount of subsidies was collected. Figure 9 compares the share of subsidies on total gross costs compared to the share of direct costs on total gross costs. One can see a very high share of subsidies for the Nordic country, which would explain low direct costs if they were using net costs for their calculation. However Finland, Sweden, and Norway use gross costs.

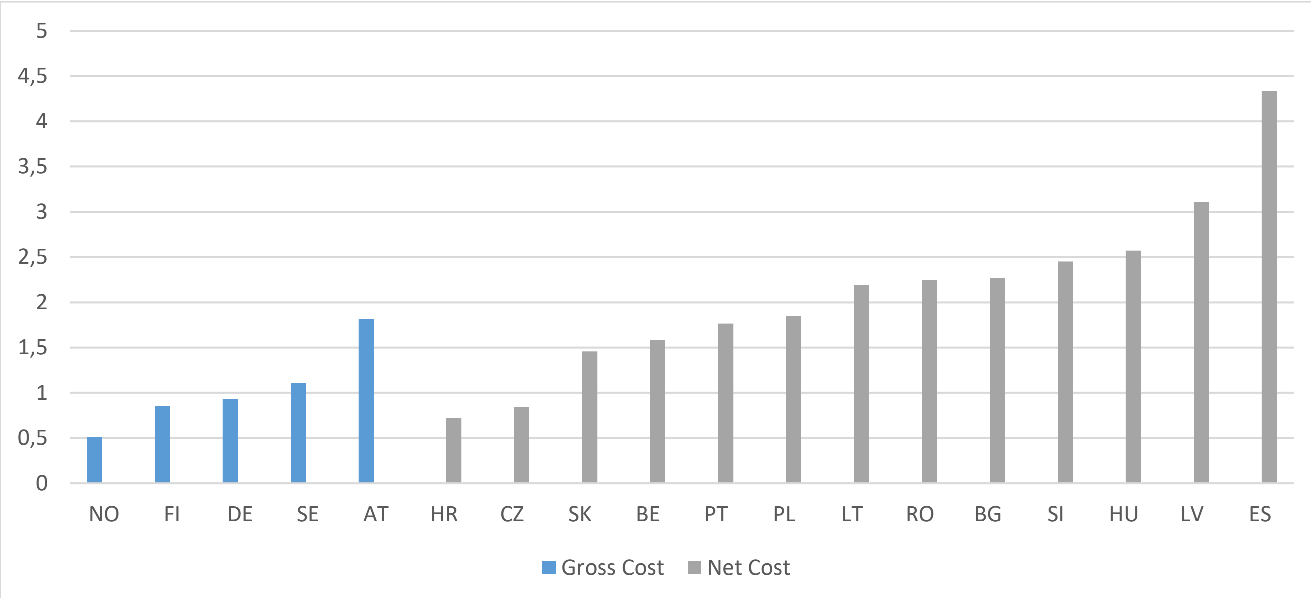
FIGURE 9: SHARES OF SUBSIDIES AND DIRECT COSTS ON TOTAL GROSS COST ACROSS COUNTRIES FOR 2019



It was also proposed that the different use of gross and net costs for the calculation of direct costs would play a role. Countries using net costs might have lower direct costs, because the cost base is reduced by the amount of subsidies. This is shown in Figure 10. On the left hand side in blue, five countries use gross costs for the calculation of direct cost which includes subsidies. Compared to the countries on the right hand side in grey, their direct costs per train km are lower which is unexpected because including subsidies would increase the costs base in particular for the cost centre renewals[41]. However, this is not the only factor to explain differences and the countries using gross costs might deduct more costs that they deem non eligible. Unfortunately, not many countries were able to provide data on the size of deducted costs in their cost modelling.

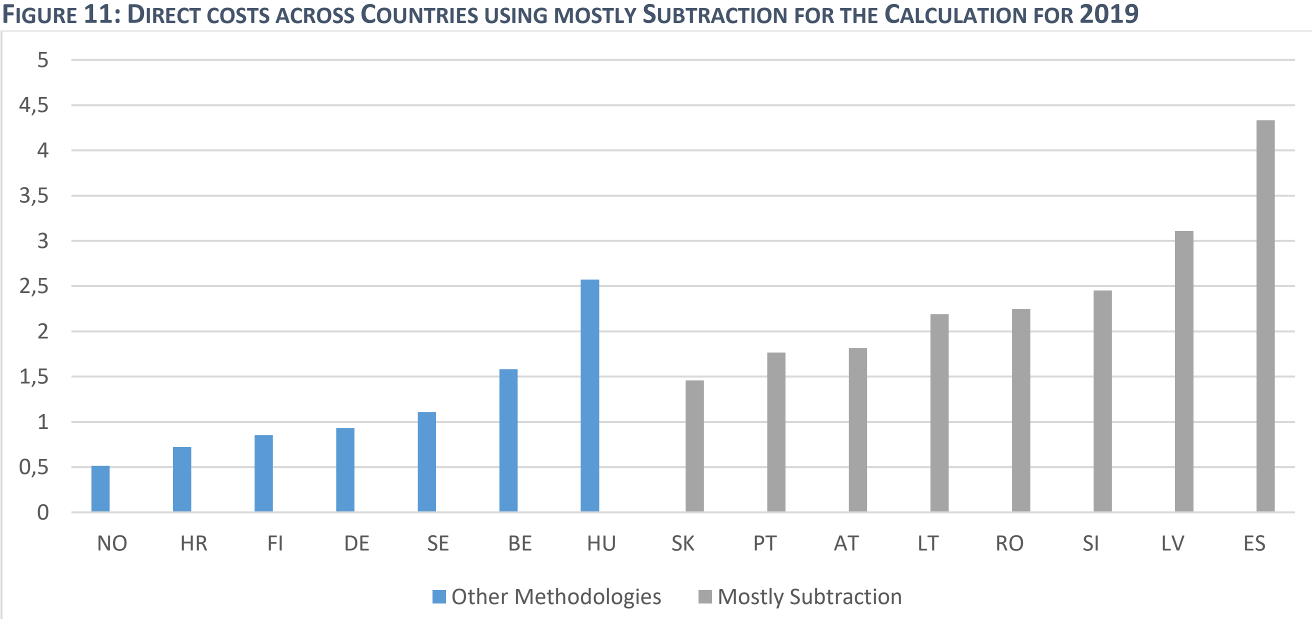
[41] One would expect a larger difference between gross and net costs for renewals because many investments in renewals are not only finance by own funds of the IM

FIGURE 10: DIRECT COSTS ACROSS COUNTRIES USING GROSS OR NET COSTS FOR THE CALCULATION FOR 2019



Another reason for differences could be that countries mostly rely on a subtraction methodology for all cost centres. Compared to countries that use econometric, engineering or mixed models, these countries might have higher direct costs per train km, because using the subtraction on its own implies a direct cost elasticity of 100%. The choice of methodology is later shown in Table 10 and the following figure splits countries by countries that do not mainly use other methodologies in blue and the ones that mainly use subtraction in two or more cost centres in grey.

FIGURE 11: DIRECT COSTS ACROSS COUNTRIES USING MOSTLY SUBTRACTION FOR THE CALCULATION FOR 2019



Some of the countries with very low direct cost per train km appear on the right hand side and use other additional methodologies than subtraction in their cost modelling. On average the difference is rather large with a weighted average of 1.08 € / Trkm for the other methodologies countries and 2.81 € / Trkm for the mostly subtraction countries. This would support the explanation that the higher implied elasticity of the subtraction methodology results in higher direct costs per train km.

7.2. Direct Costs per Service

Next, the paper addresses the direct cost per train km for each main service. Table 8 shows the weighted average, minimum, maximum and the number of countries on which these numbers are based. A weighted average is necessary to take account of the different network sizes. Looking at the minimum and maximum, the range is rather wide. This is shown in the following graphs.

It seems that freight and non-PSO services pay on average higher direct cost charges, which might be warranted due to their stronger utilisation of the infrastructure due to their weight or high speed.

TABLE 8: SUMMARY STATISTICS ACROSS MAIN SERVICES

Service	Freight	Non PSO	PSO	Total
Weighted Average	1.97 €/Trkm	2.19 €/Trkm	1.25 €/Trkm	1.54 €/Trkm
Minimum	0.98 €/Trkm	0.20 €/Trkm	0.32 €/Trkm	0.51 €/Trkm
Maximum	4.54 €/Trkm	5.16 €/Trkm	3.77 €/Trkm	4.33 €/Trkm
Number	14	9	14	18

Figure 12 shows a wide range of level of direct cost per Train km for freight. Spain has the highest charges for the same reason that was given at the beginning of Section 7.1 and for Figure 8. The same applies to Lithuania and Latvia. Norway is the only country where direct cost charges per train km are below 1 € / Trkm. The reasons for this might be that charges are calculated in tonne km and that some very heave freight trains run frequently but not for a very long distance.

FIGURE 12: DIRECT COST PER TRKM FOR FREIGHT SERVICES ACROSS COUNTRIES FOR 2019

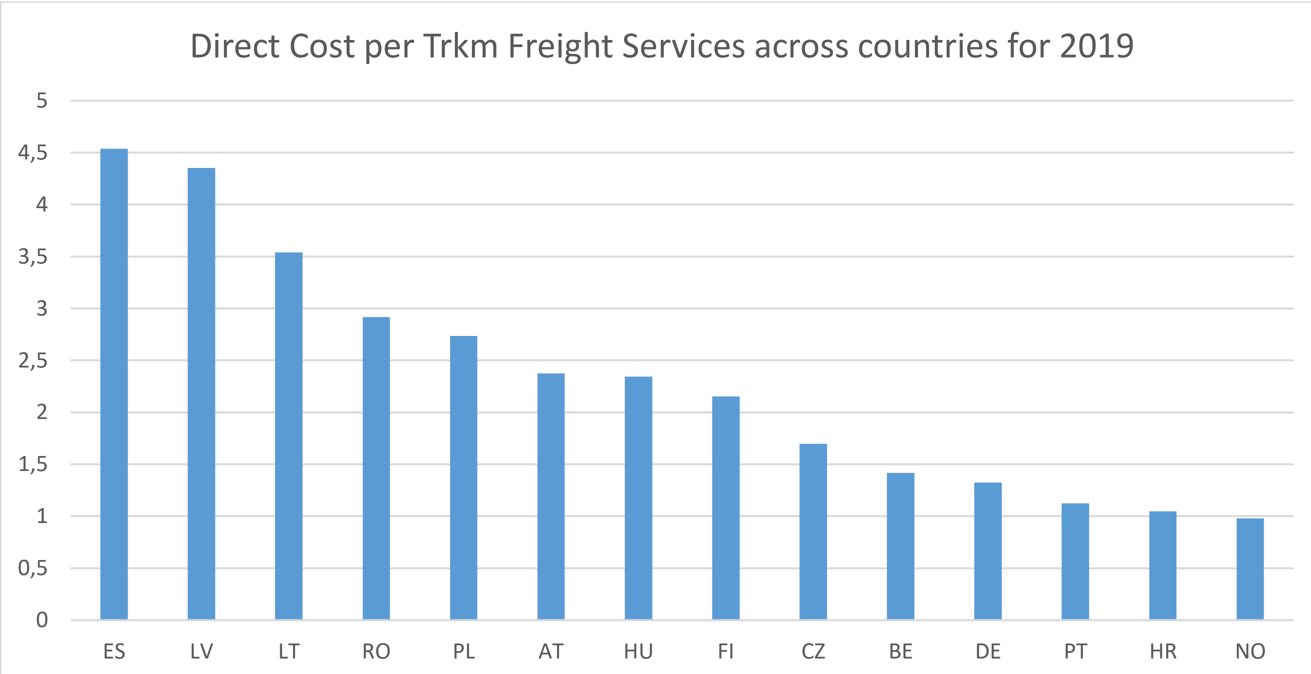


Figure 13 shows the direct cost per Train km for PSO Services. Again, Spain shows the highest charges with a greater distance to all other countries than for freight. Only Spain and Hungary have PSO direct cost charges per train-km above 2 €. Lithuania and Finland have the lowest level with direct cost below 0.5 € per train-km. A wide range of direct cost level can also be observed.

FIGURE 13: DIRECT COST PER TRKM FOR PSO SERVICES ACROSS COUNTRIES FOR 2019

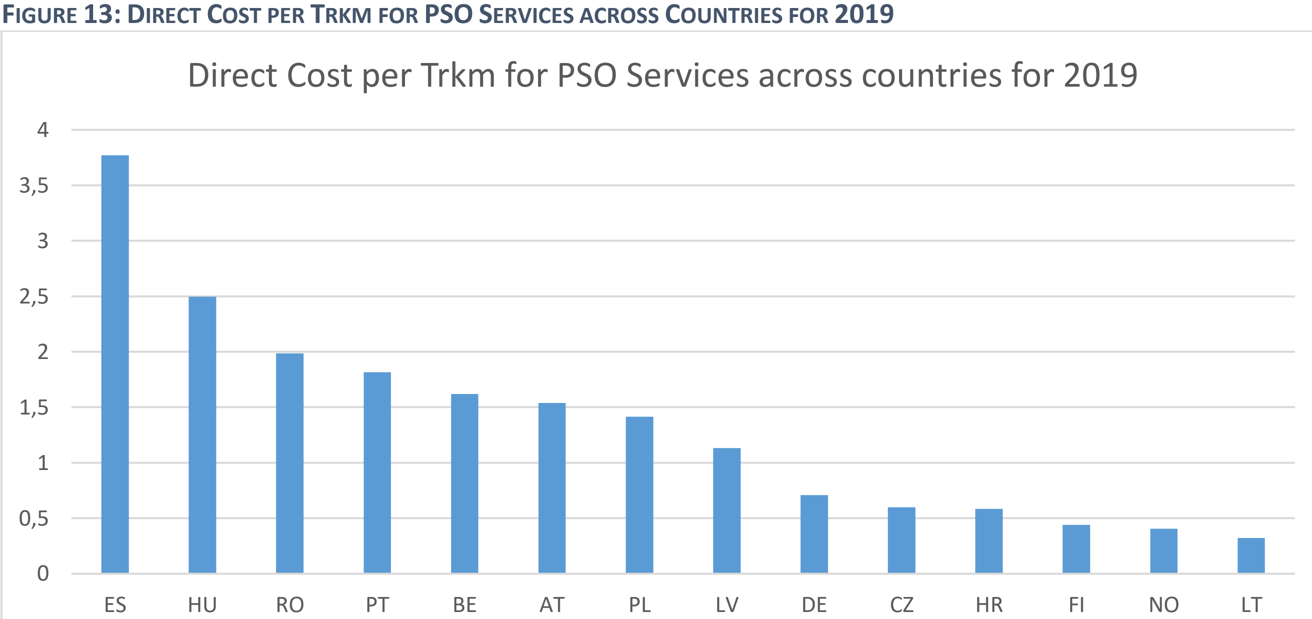


Figure 14 shows the direct cost per Train km for non-PSO Services. Beyond the wide range of levels already observed in the other services. Austria and Spain have the highest level (above 5 € per train-km). Czech Republic and Finland have the lowest level (below 0.5 € per train-km).

FIGURE 14: DIRECT COST PER TRKM FOR NON-PSO SERVICES ACROSS COUNTRIES FOR 2019

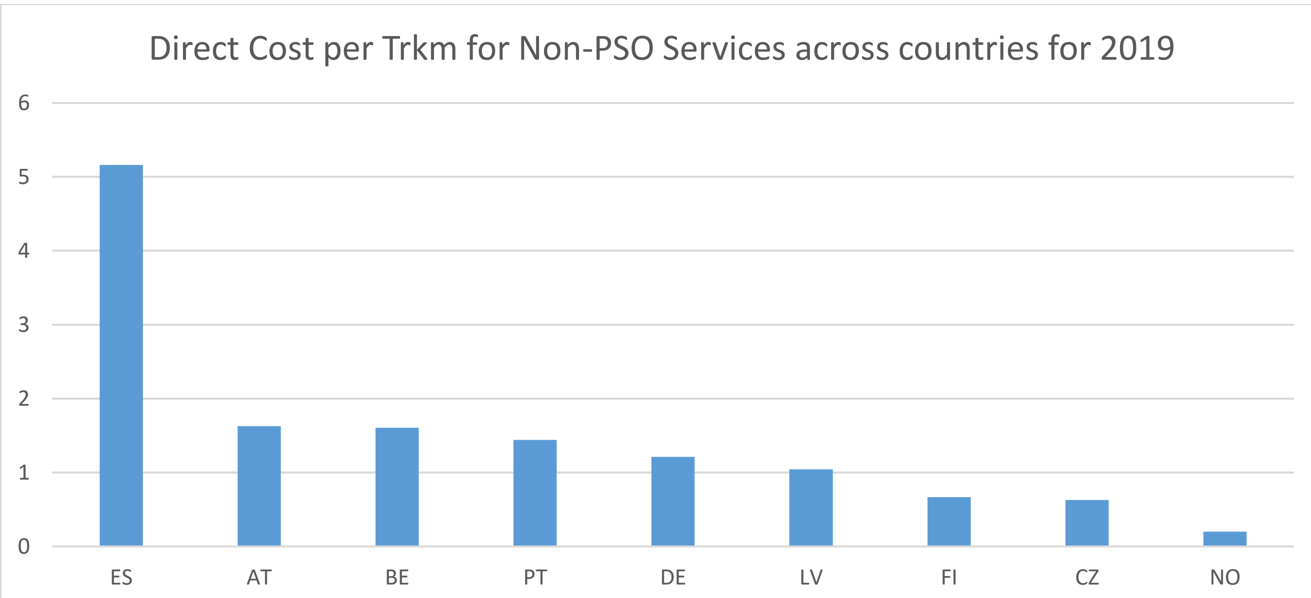


Figure 15 shows the share of direct cost per main services and is ordered by the size of the share of freight. The Baltic countries and Finland have the highest share for freight. In Latvia and Lithuania this might also be due to the high share of freight over total traffic of roughly 60 % in both countries. Not all countries provided data on Non PSO services so that the split is usually just between PSO and freight. Sweden for instance, only has data on passenger services as a whole. Austria, Germany, and Spain have large shares of non-PSO services. In Germany, this is the long distance travel offered by DB Fernverkehr.

FIGURE 15: SHARE OF DIRECT COST PER MAIN SERVICES ACROSS COUNTRIES FOR 2019

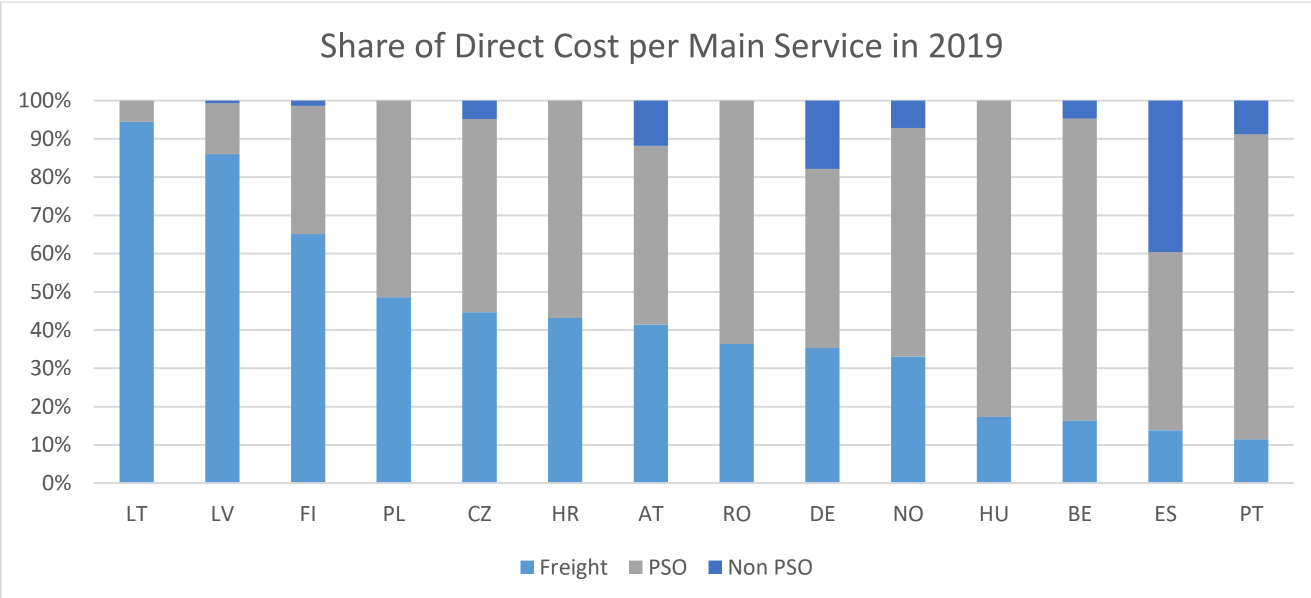
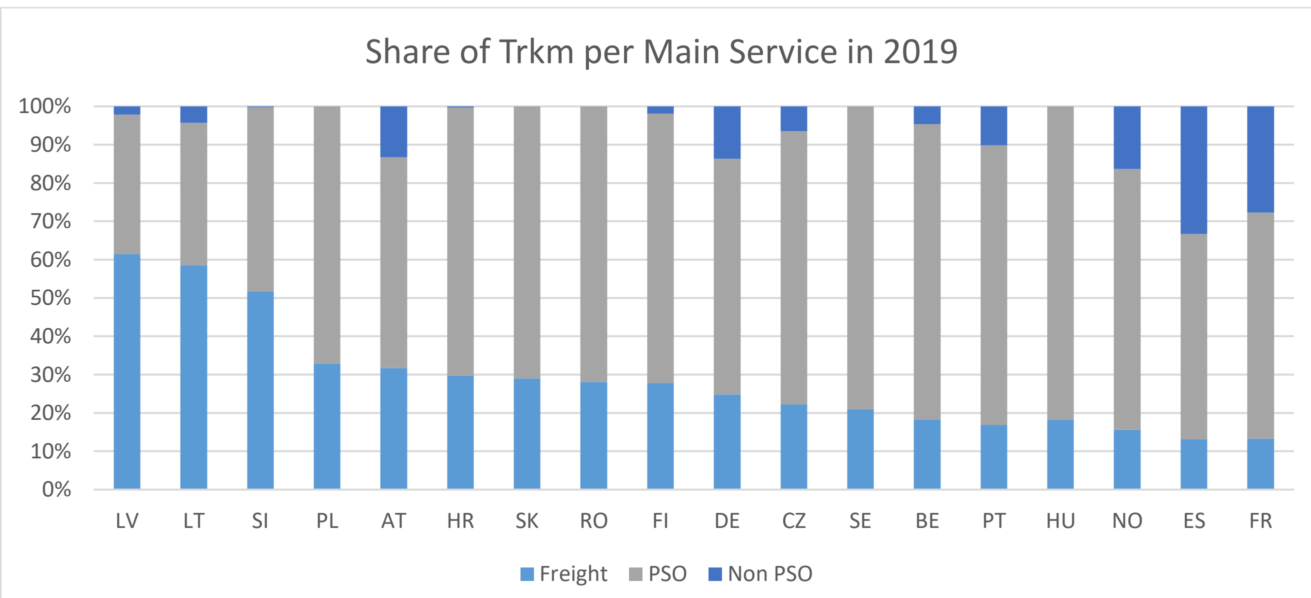


FIGURE 16: SHARE OF TRAIN KM PER MAIN SERVICES ACROSS COUNTRIES FOR 2019

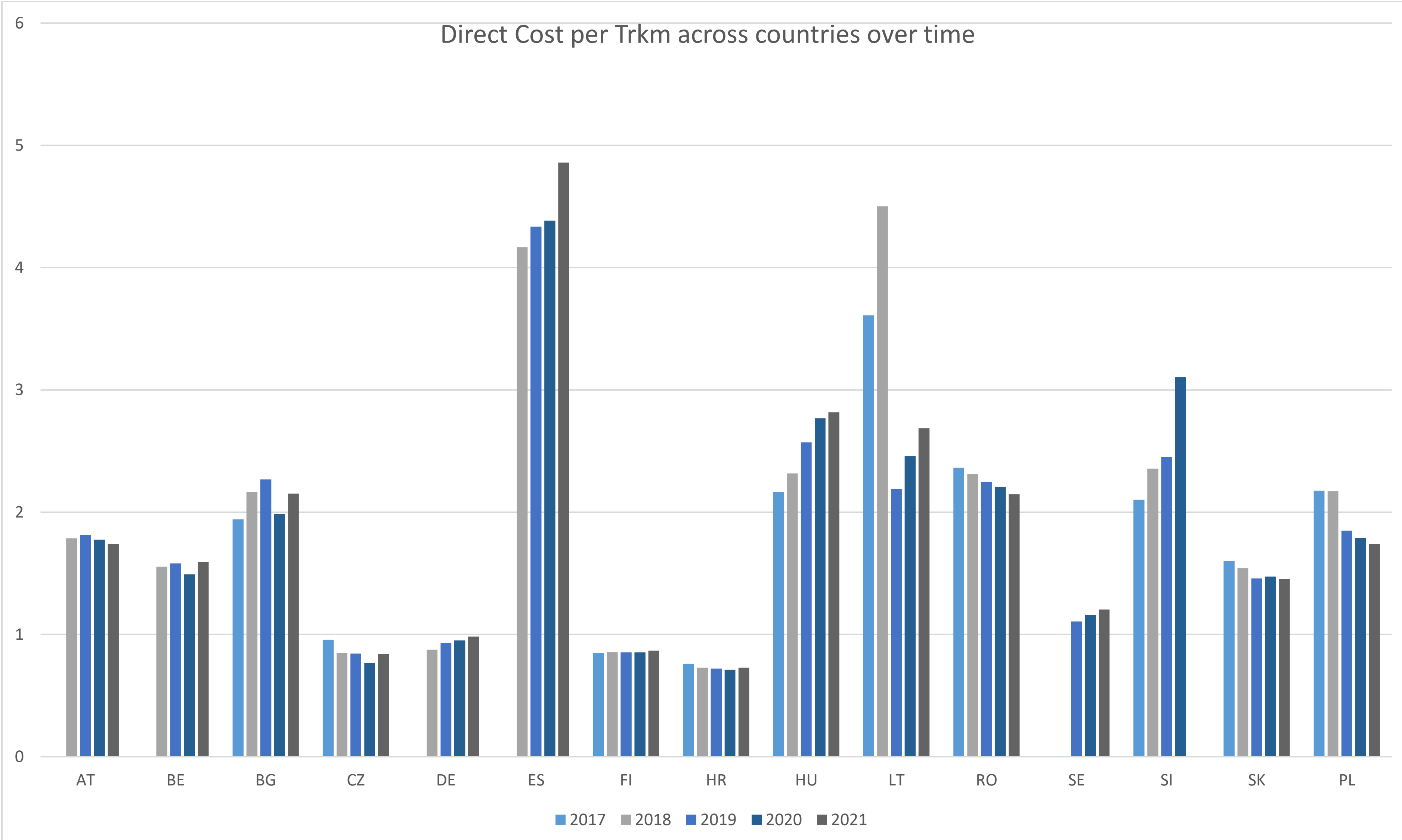


7.3. Direct Costs over Time

Many countries also provided direct cost data for the years from 2017 to 2021, so that this paper is able to analyse the development over time as shown in Figure 17. For many countries the direct costs per train km remains fairly constant or even decreases. There are some countries (Germany, Hungary, Spain, Finland, Sweden and Slovenia) where the charge has increased moderately.

In Spain a strong increase is observed for 2021, which is explained by the significant reduction in the traffic forecast of the IM for 2021, due to restrictions implemented during the COVID pandemic. Given that the current direct cost calculation model used by the IM is based on historical costs, a reduction in the expected traffic leads to an increase in unitary direct costs for the applicable year. The development in Lithuania is due to the system change discussed at the beginning of this section for ex-ante vs ex-post values.

FIGURE 17: DIRECT COST PER TRKM ACROSS COUNTRIES FROM 2017 TO 2021



Furthermore, one might expect a correlation between direct cost and train km in way that direct cost would increase with traffic. Looking at a pairwise comparison of the compound annual growth rate (CAGR) across countries, there are some countries where traffic has been on average reducing since 2017 while direct cost has increased or not reduced as much. This can be visualized graphically in Figure 18 or using the numbers in

Table 9. This also shows the years of reference used for the calculation. Both are ordered by the CAGR of direct cost in decreasing order.

FIGURE 18: CAGR OF DIRECT COST AND TRKM SINCE 2017

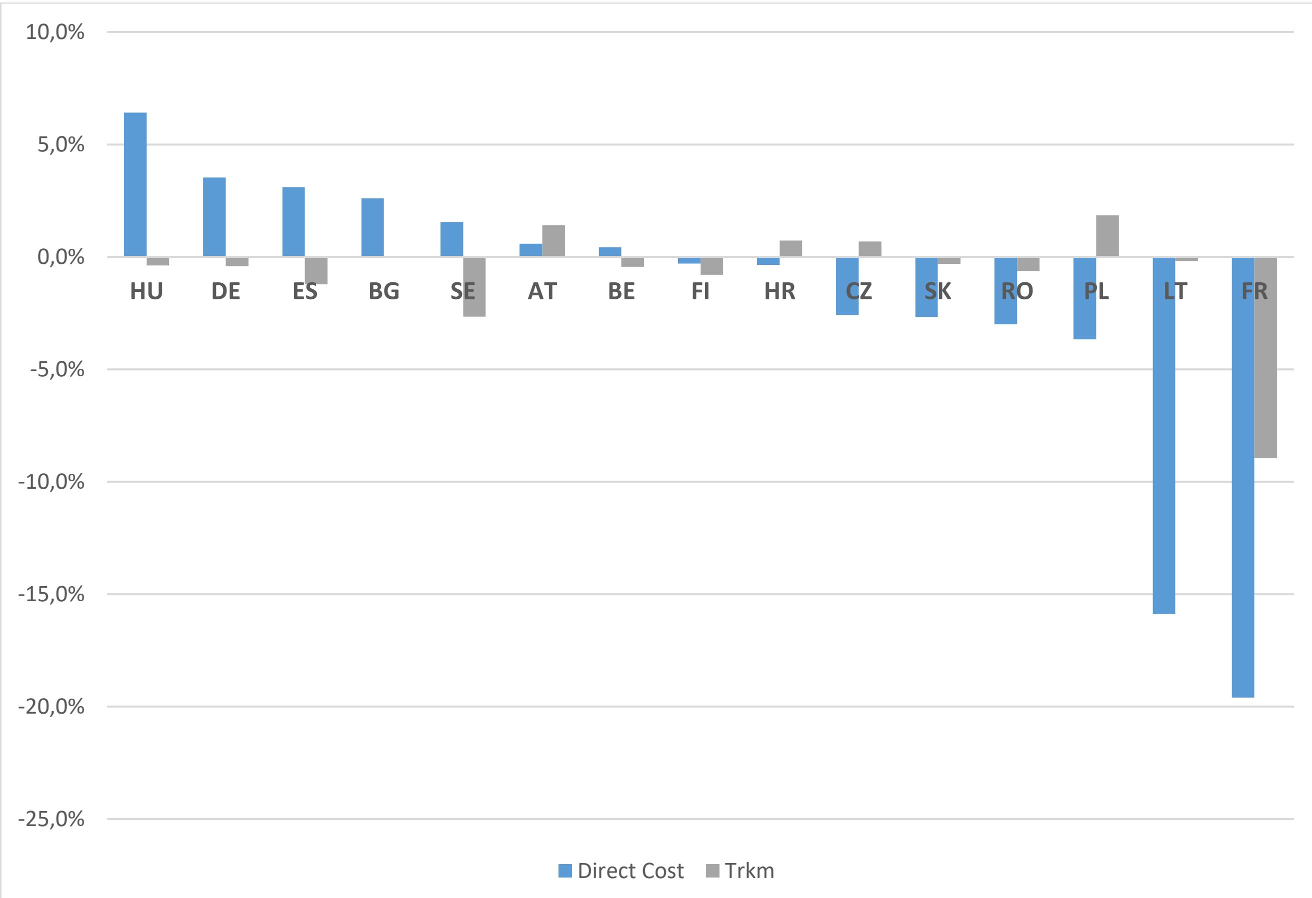


TABLE 9: CAGR OF DIRECT COST AND TRKM SINCE 2017

Country	From	To	Direct Cost CAGR	Trkm CAGR
Hungary	2017	2021	6,4%	-0,4%
Slovenia	2017	2020	5,9%	-7,1%
Germany	2018	2021	3,5%	-0,4%
Spain	2017	2021	3,1%	-1,2%
Bulgaria	2017	2021	2,6%	0,0%
Sweden	2019	2021	1,6%	-2,7%
Austria	2018	2021	0,6%	1,4%
Belgium	2018	2021	0,4%	-0,4%
Finland	2017	2021	-0,3%	-0,8%
Croatia	2017	2021	-0,4%	0,7%
Czech Republic	2017	2021	-2,6%	0,7%
Slovakia	2017	2021	-2,7%	-0,3%
Romania	2017	2021	-3,0%	-0,6%
Poland	2017	2021	-3,7%	1,8%
Lithuania	2017	2021	-15,9%	-0,2%
France	2017	2020	-19,6%	-8,9%

Spain shows a strong average increase of direct cost while train km actually decreases. Some countries on the right side of Figure 18 show average reductions of direct cost, but only in France this is accompanied by a reduction in train km.

In Spain during the last few years, the RB has observed that direct cost as calculated by the IM and actual traffic grew at a different rates. This is particularly relevant on the high-speed network where, due to the pandemic restrictions, traffic decreased drastically, while total amount of direct cost increased. This fact does not match with the definition of direct cost as a proxy for marginal cost. Therefore, the RB indicated that the current cost model used by the IM to calculate charges could be failing in properly estimating direct cost, and announced a future more in-depth analysis of the model.

For France, the strong decrease is explained by the fact that SNCF Réseau has significantly improved its method for estimating the direct cost as described in the 2019 Network Statement, in particular:

- the use of a "Trans-log" type of modelling for the econometric estimates, which helps to improve the reliability of the proposed results
- the integration of tonnage as a measure of traffic and as a unit of work for estimating the costs of tracks and switches.

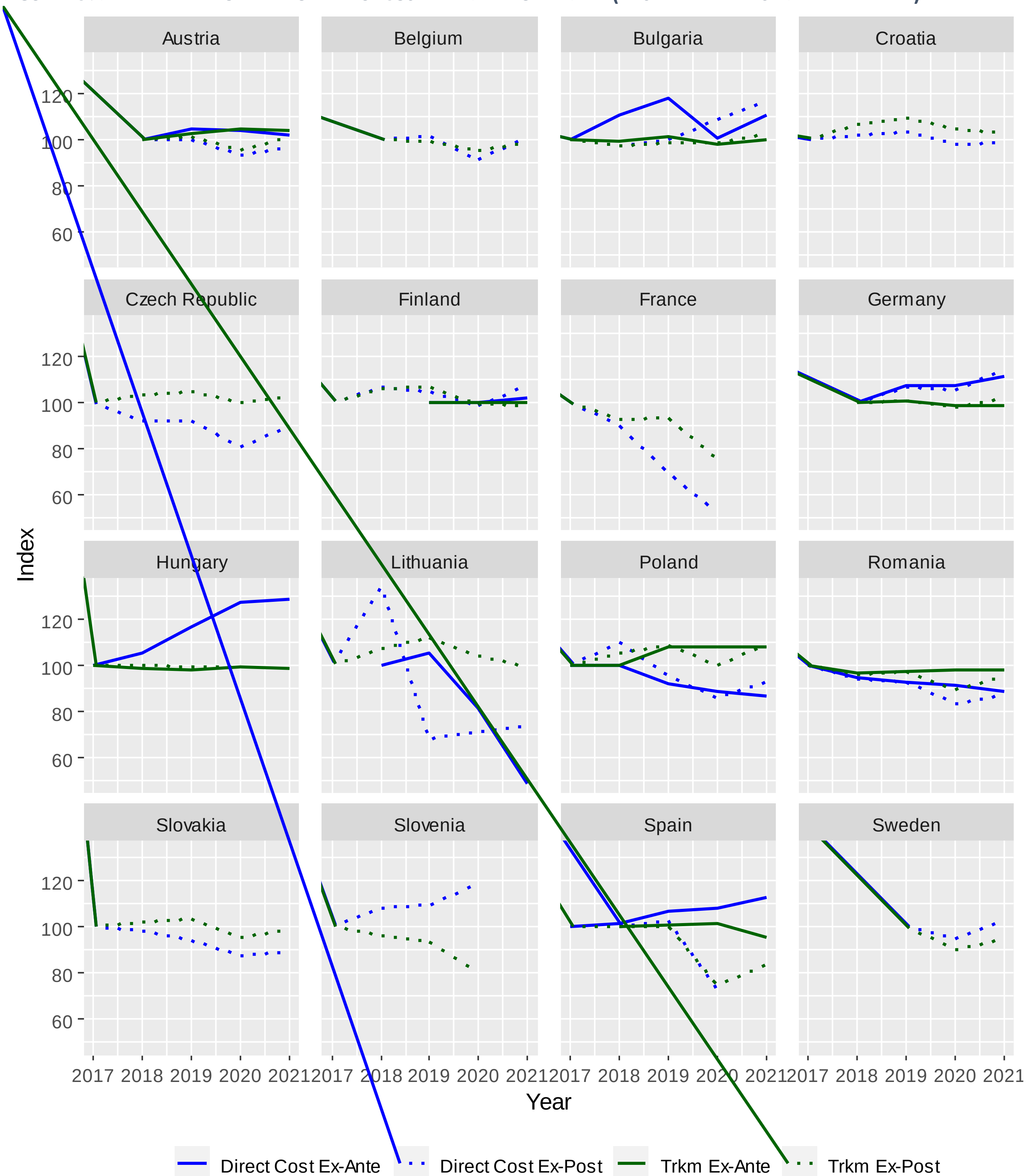
The introduction of this parameter is justified by the fact that the weight of trains has a substantial impact on the wear and tear of a number of railway installations they use. The costs of maintaining and renewing track and switches and crossings depend on the tonnage used. Therefore, the calculation of the running charge (redevance de circulation) is based on two units of work: the train km and the tonne km. This improvement related to the estimation method and the inclusion of an additional unit of work results in a decrease of more than EUR 500 million in the revised direct cost for 2019 for passenger services compared to the previous timetable

Another way of looking at the relationship between direct cost and train km over time would be to create country specific indices starting at 100 for both train km and direct cost in the earliest year (usually 2017). One would expect to see some correlation between both factors in a way that if train km go up direct cost should follow. In many countries both factors do not fluctuate that much. It might be that the relationship is lagged due to methodological issues. In many countries, direct costs are calculated based on historical data that lags behind by several years. This is shown in the following Figure 19, which shows a similar development as in Figure 17.

Figure 19 shows both ex-ante and ex-post direct costs and train km. Direct costs are shown in blue and train km in dark green. Ex-ante values are shown as a solid line while ex-post values are shown as a dotted line. The solid and dotted lines differ similarly as shown in Figure 6 and Figure 7. There seems to be no discernible pattern that would explain a direct relationship between train km and direct costs. One might have expected a lagged response of direct costs on changes in train km.

Further regression analysis of the impact of train km on direct cost did not show any highly significant effects as soon as country specific fixed effects were considered. Different specifications using a log-log form, annual growth rates or the transformed index values did not yield any significant effect. For this paper, data was only available from 2017 to 2021 as direct cost have mostly been introduced from 2017. Data for 2022 is not yet available. Maybe with time, longer time series can yield more insights on the relationship between direct cost and train km. One could also look if there is a lagged relationship. For instance there could be a lag of the impact of changes in traffic on direct costs as some countries use historic data for the calculation of direct costs.

FIGURE 19: INDEXED DEVELOPMENT OF DIRECT COST AND TRKM OVER TIME (BASE YEAR EARLIEST YEAR AVAILABLE)



7.4. Qualitative Questions

Section 5.1 discussed the different methodologies that can be used for the calculations of direct costs. Table 3 showed which methods are used in general within the different systems. The data collection section further explored the usage of methodologies for the different costs centres shown in the table below. Four possible categories are possible:

- Subtraction
  Indicates that no further methodology is used within the cost centre or the impact is negligible
- Engineering or econometric
  Indicates that the methodology within the cost centre mostly relies on engineering or econometrics. A subtraction step can take place beforehand, but is not the main driver of the methodology.
- Mixed
  Same as above but just a mixture of methodology, most likely engineering and econometrics
- Not included
  If this centre is not part of the calculation methodology

The results are shown in Table 10 which also shows the cost base used for the calculations for direct costs. A few countries use gross costs, which means including subsidies, for the calculation of direct costs while the rest uses net costs, which means that subsidies are deducted before the calculation.

TABLE 10: METHODOLOGY PER COST CENTRE AND COST BASE PER COUNTRY

Country	Operations	Maintenance	Renewals	Subsidies included Cost base used
Austria	Subtraction	Subtraction	Engineering	Gross Cost
Belgium	Engineering	Engineering	Not included	Net Cost
Bulgaria	Other			Net Cost
Croatia	Mixed	Engineering	Not included	Net Cost
Czech Republic				Net Cost
Finland	Mixed	Mixed	Mixed	Gross Cost
France	Econometric	Econometric	Econometric	Net Cost
Germany	Engineering	Engineering	Econometric	Gross Cost
Hungary	Mixed	Mixed	Mixed	Net Cost
Latvia	Subtraction	Subtraction	Subtraction	Net Cost
Lithuania	Subtraction	Subtraction	Subtraction	Net Cost
the Netherlands	Econometric	Mixed	Mixed	Net Cost
Norway	Not included	Econometric	Not included	Gross Cost
Poland		Other		Net Cost
Portugal	Subtraction	Subtraction	Not included	Net Cost
Romania	Subtraction	Subtraction	Subtraction	Net Cost
Slovakia	Subtraction	Subtraction	Subtraction	Net Cost
Slovenia	Subtraction	Subtraction	Subtraction	Net Cost
Spain	Subtraction	Subtraction	Subtraction	Net Cost

Sweden	Econometric	Econometric	Econometric	Gross Cost

7.5. Representative Trains

This paper aims to examine direct cost charges to provide a benchmark for European countries[42]. In order to establish a proper comparison between countries, a set of representative trains has been proposed, taking into account the type of service, engine, weight and speed (see Table 6 in Section 6).

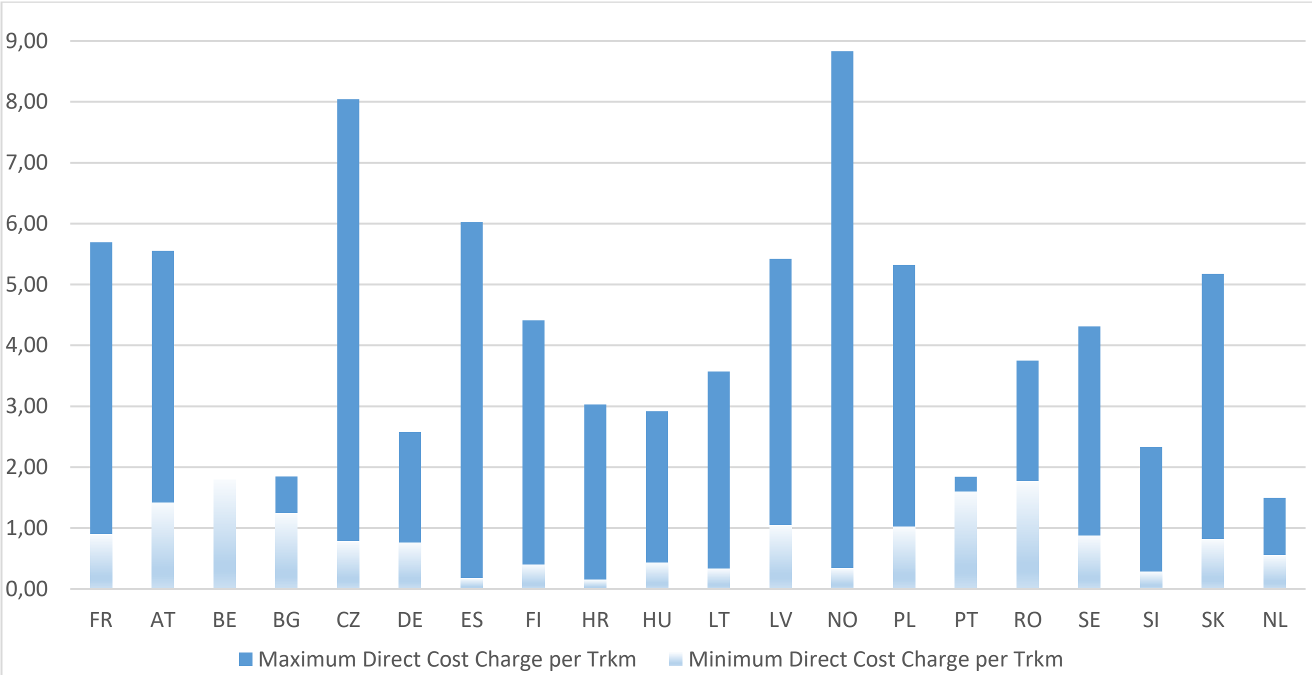
In this section, the graphs always show the minimum and maximum direct cost charge per train km in a two coloured horizontal or vertical bar. The light blue lower / left part of the bar indicates the minimum value whereas the dark blue part on the upper / right part of the bar indicates the range and finishes at the maximum value. The two-coloured bar is needed to be able to show countries where the minimum and maximum value coincide and there is no range. The illustration allows the reader to easily compare the range of direct cost charges across countries.

Total range

According to the data gathered for 2022, the minimum direct cost charge per Train km is below 1€/Trkm in most of the responding countries, ranging from 0.15€/Trkm in Croatia to 1.79€/Trkm in Belgium (see Figure 20). Belgium is a special case, as the direct cost charge is the same for all types of representative trains, hence only the light blue coloured bar. On the other hand, there is greater variation in the maximum direct cost charges paid by RUs. For instance, in the Netherlands operators bear a maximum of 1.50€/Trkm, while this cost can reach 8.83€/Trkm in Norway. This maximum charge applies to very heavy iron ore trains that run in a particular section of the network for which the modelling calculated the highest direct cost charges of the entire network. Furthermore, the phasing-in scheme ended in 2021. The explanation is similar for the Czech Republic. The maximum charge would apply for trains over 2,000 tonnes and charges only depend on gross tonnes. However those trains are very rare, because of length limits and high track gradients necessitating two locomotives.

[42] In the case of France, the amount does not correspond to what will actually be paid by the railway undertakings in the case of freight services as part of the charges are supported by the State.

FIGURE 20: DIRECT COST CHARGE PER TRKM FOR 2022

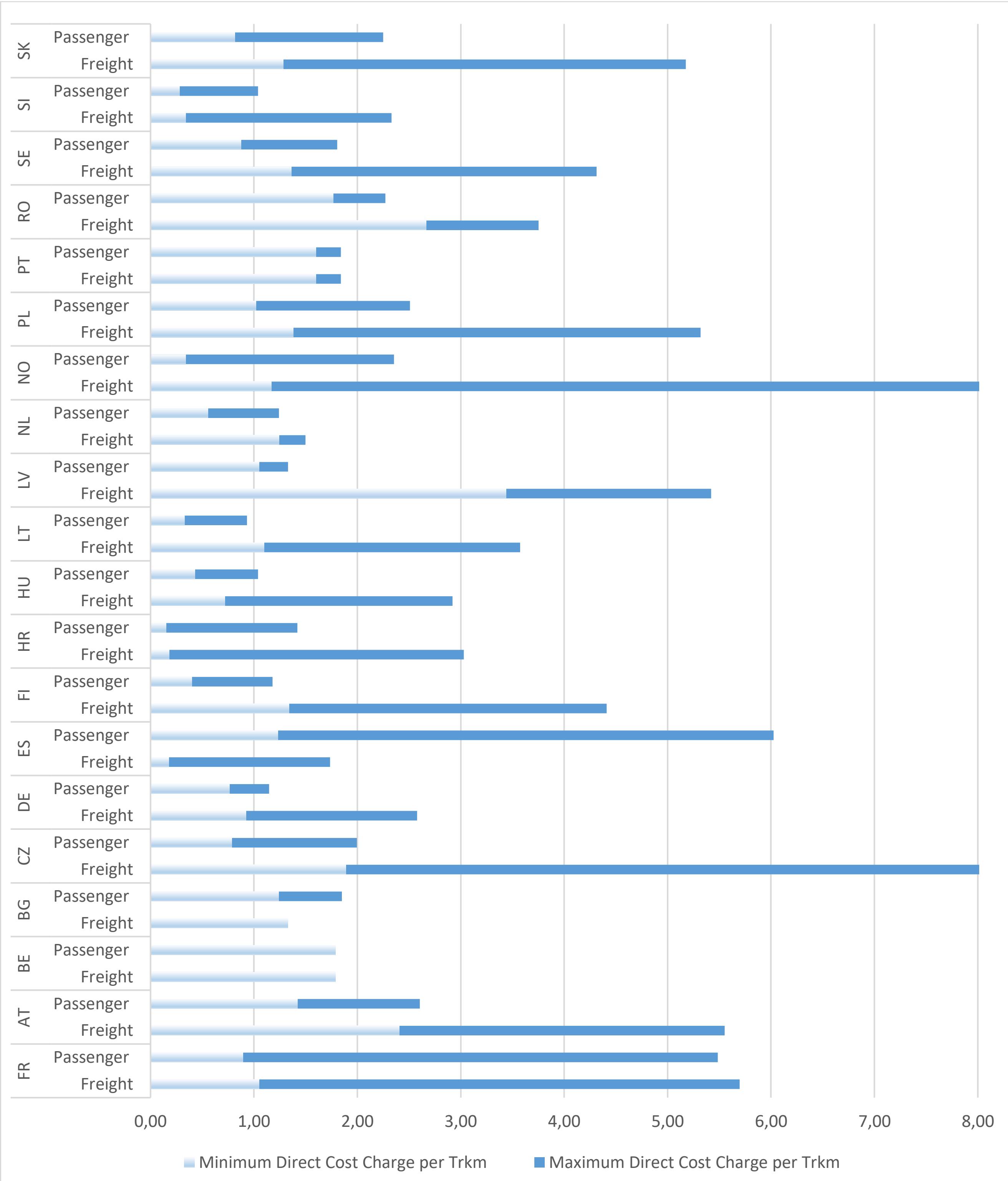


Range per main service

As can be seen in the graph below, in most countries the direct cost per train-kilometre associated with freight services is higher than that of passenger services. Due to several reasons, such as mass and axle loads, freight trains can produce more intense wear and tear on the tracks compared to passenger trains and this results in higher direct cost paid by RUs.

For passenger transport, the average minimum direct cost charge is 0.89€/Trkm, while for freight it reaches 1.37€/Trkm in 2022. As for the maximum direct cost charge, the average value is 2.11€/Trkm for passengers and 3.96€/Trkm for freight.

FIGURE 21: DIRECT COST CHARGE PER TRKM BY SERVICE FOR 2022



Electric vs Diesel

The information gathered on direct cost charges shows that approximately half of the countries that participated in the data collection process make a distinction according to the type of engine used by the trains running on the rail network. This is the case in Bulgaria, Croatia, Finland, France, Hungary, Latvia, Lithuania, Poland, Portugal, Romania, Slovakia, and Spain.

In countries where the cost varies depending on the train engine, the cost borne by RUs using electric vehicles is higher than those using diesel. Specifically, as can be seen in Figure 22 and Figure 23, the minimum direct cost charge of freight trains with electric engines is, on average, 25% higher than those using diesel and 7% higher in the case of the maximum cost.[43] For PSO passenger services, the minimum cost charge for electric-powered trains is, on average, 37% higher than for diesel and 32% higher when considering maximum cost.

[43] This is based on an unweighted average of percentage differences across countries.

FIGURE 22: DIRECT COST CHARGE FOR FREIGHT SERVICES PER TRKM BY ENGINE FOR 2022

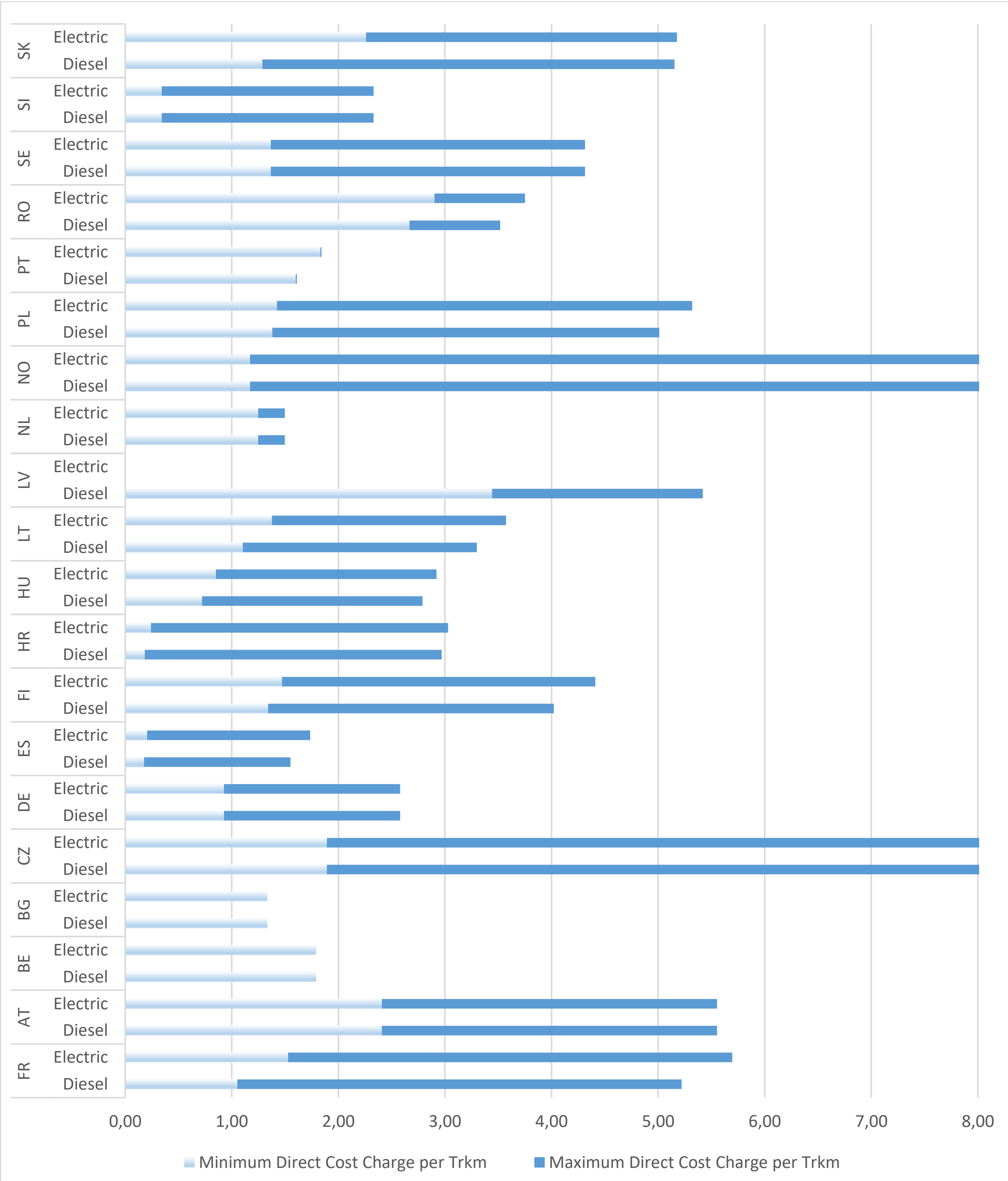
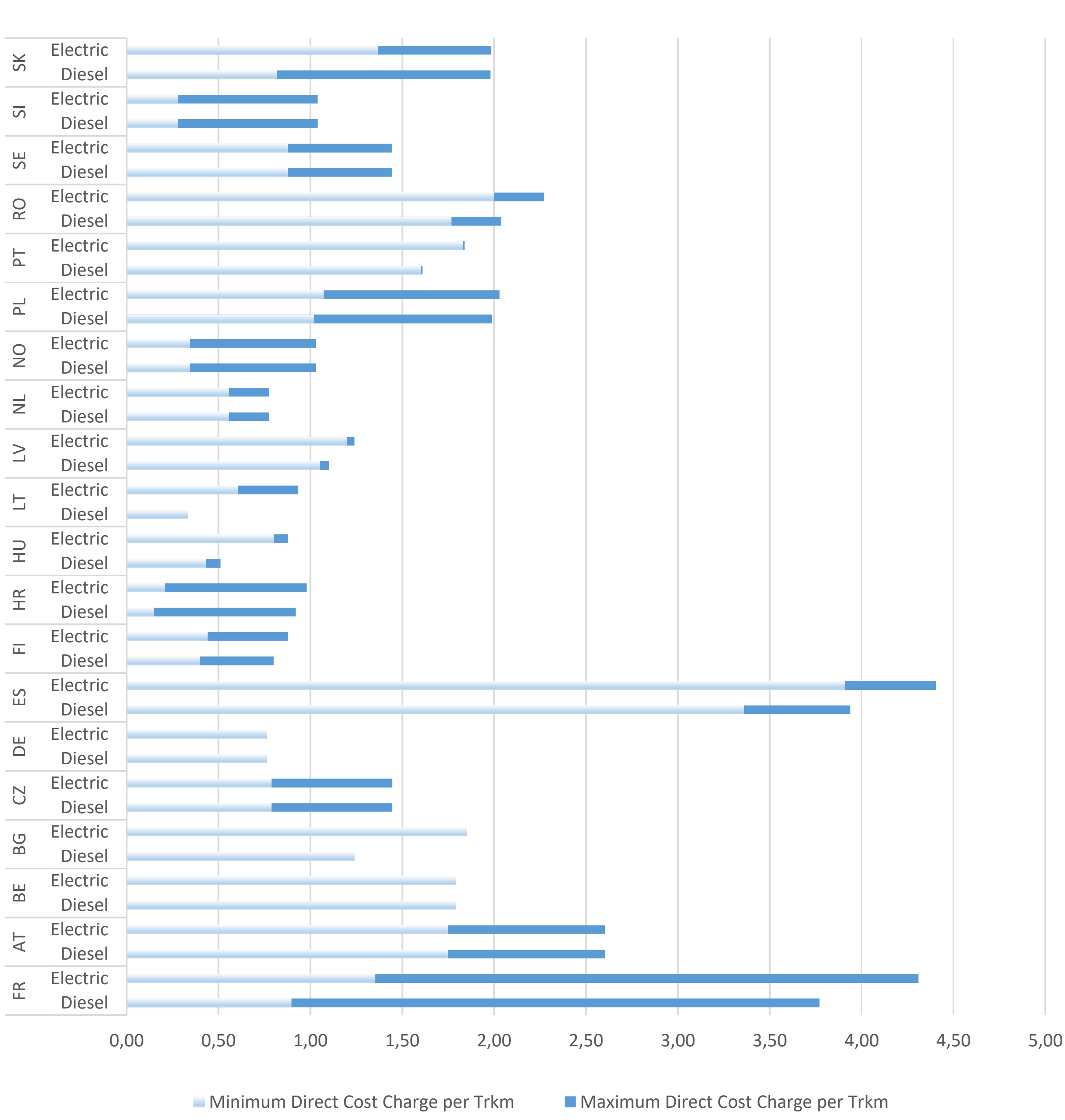


FIGURE 23: DIRECT COST CHARGE FOR PSO SERVICES PER TRKM BY ENGINE FOR 2022



Weight

Another variable that can affect the calculation of direct cost charges is the weight of the rolling stock, since the heavier a train is, the more wear and tear it produces on the infrastructure. In fact, to account for this impact on the network, the direct cost differs according to the mass of the train in a large number of countries. Specifically, 16 out of 20 countries report for freight services and 11 out of 20 countries report for passenger services that the cost borne by RUs varies with weight.

Thus, according to the data collected, a representative freight train of 1000 tonnes pays on average between 1.37€/Trkm and -2.04€/Trkm, while these values reach 2.73€/Trkm and 3.96€/Trkm for a train of 3000 tons. However, there is great variability among countries in terms of the minimum and maximum direct cost charge borne by freight operators (see Figure 24). For example, a 3000 tonne train would pay a minimum of 0.18€/Trkm in Spain and 6.99€/Trkm in the Czech Republic.

In the case of long distance (non-PSO) passenger services, the minimum direct cost for a representative 400 tonne train is on average 1.02€/Trkm and the maximum is on average 1.63€/Trkm, while these values reach 1.34€/Trkm and 2.11€/Trkm in the case of an 800 tonne train (see Figure 25).

FIGURE 24. DIRECT COST CHARGE FOR FREIGHT SERVICES PER TRKM BY WEIGHT FOR 2022

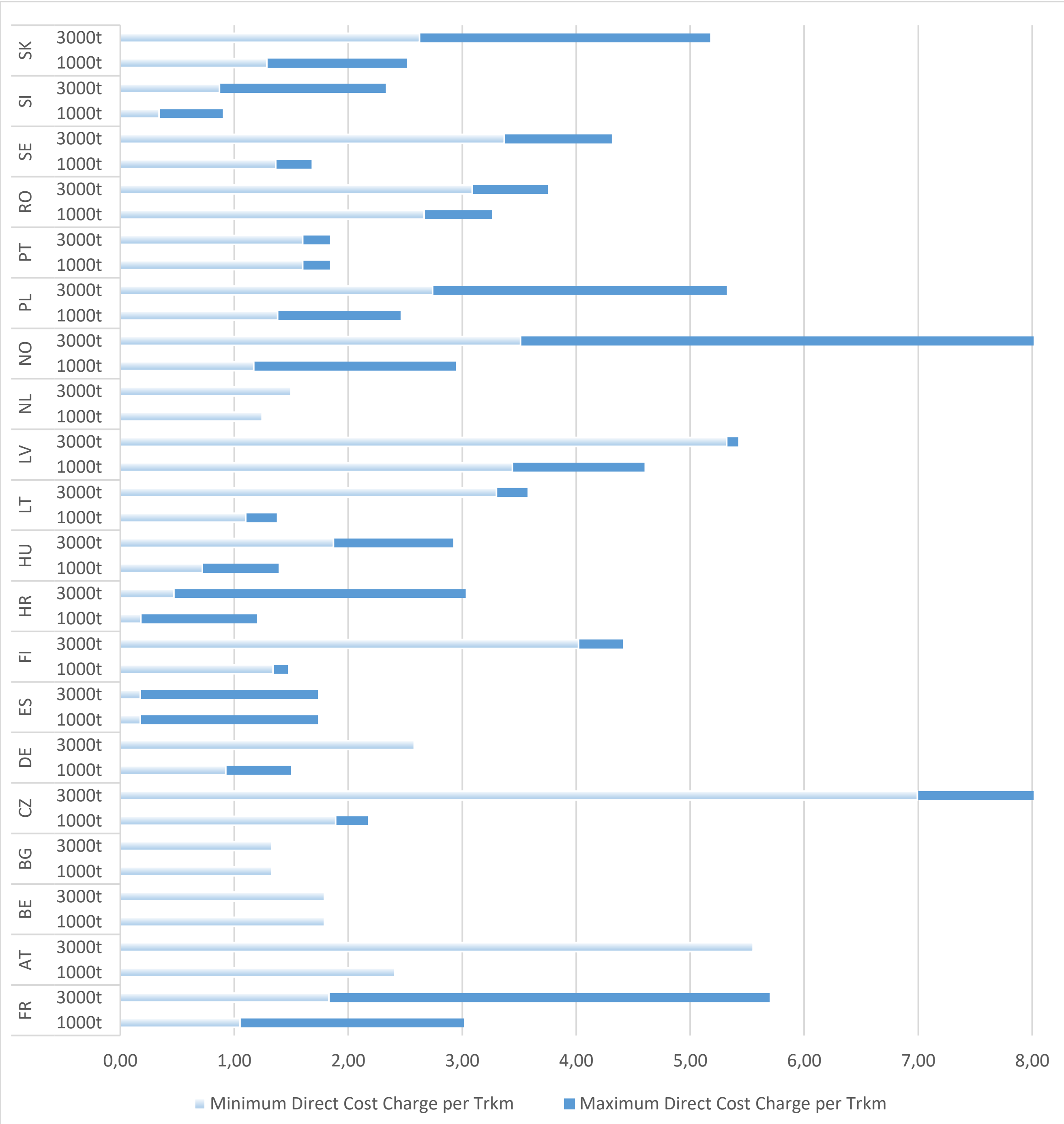
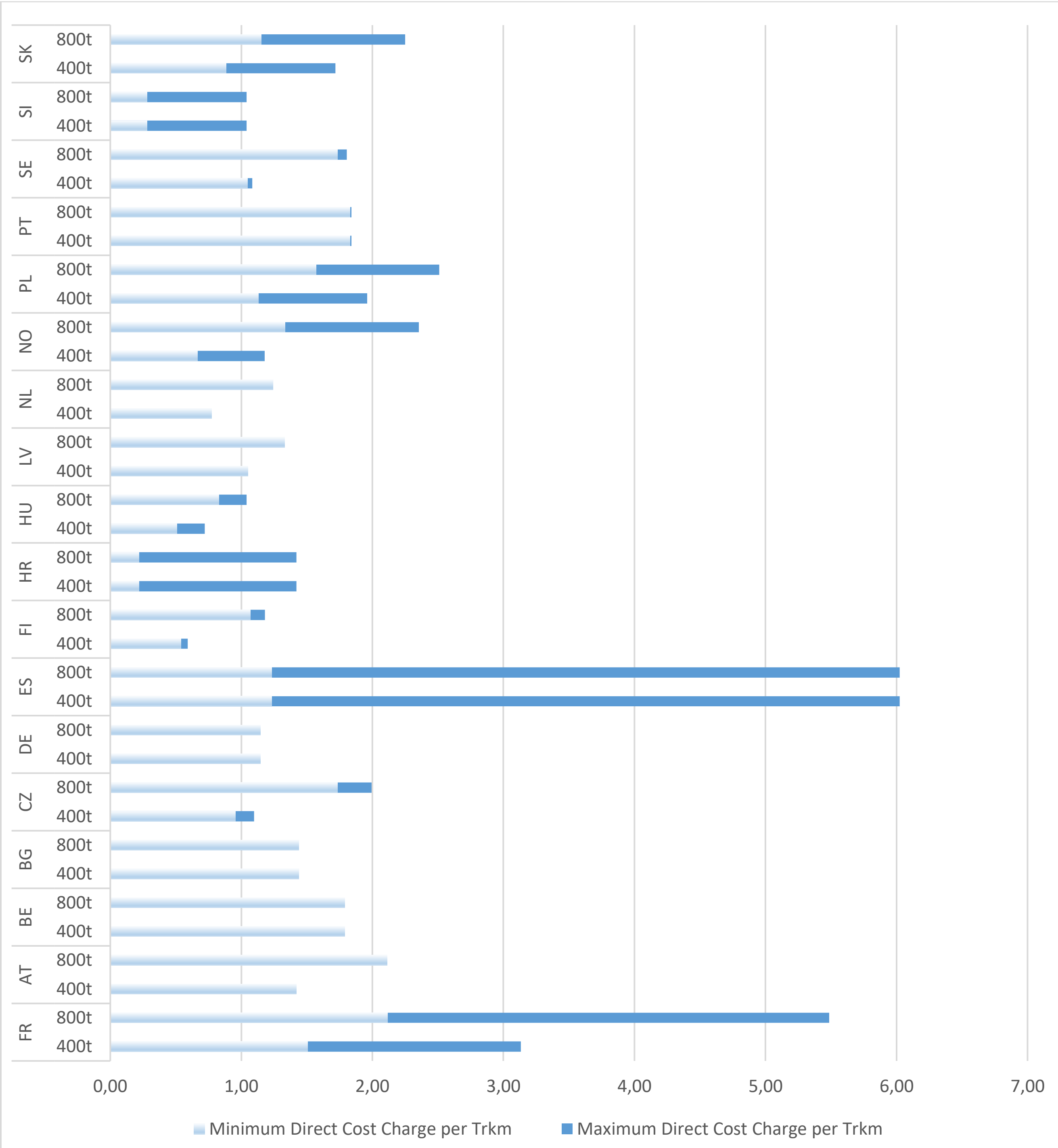


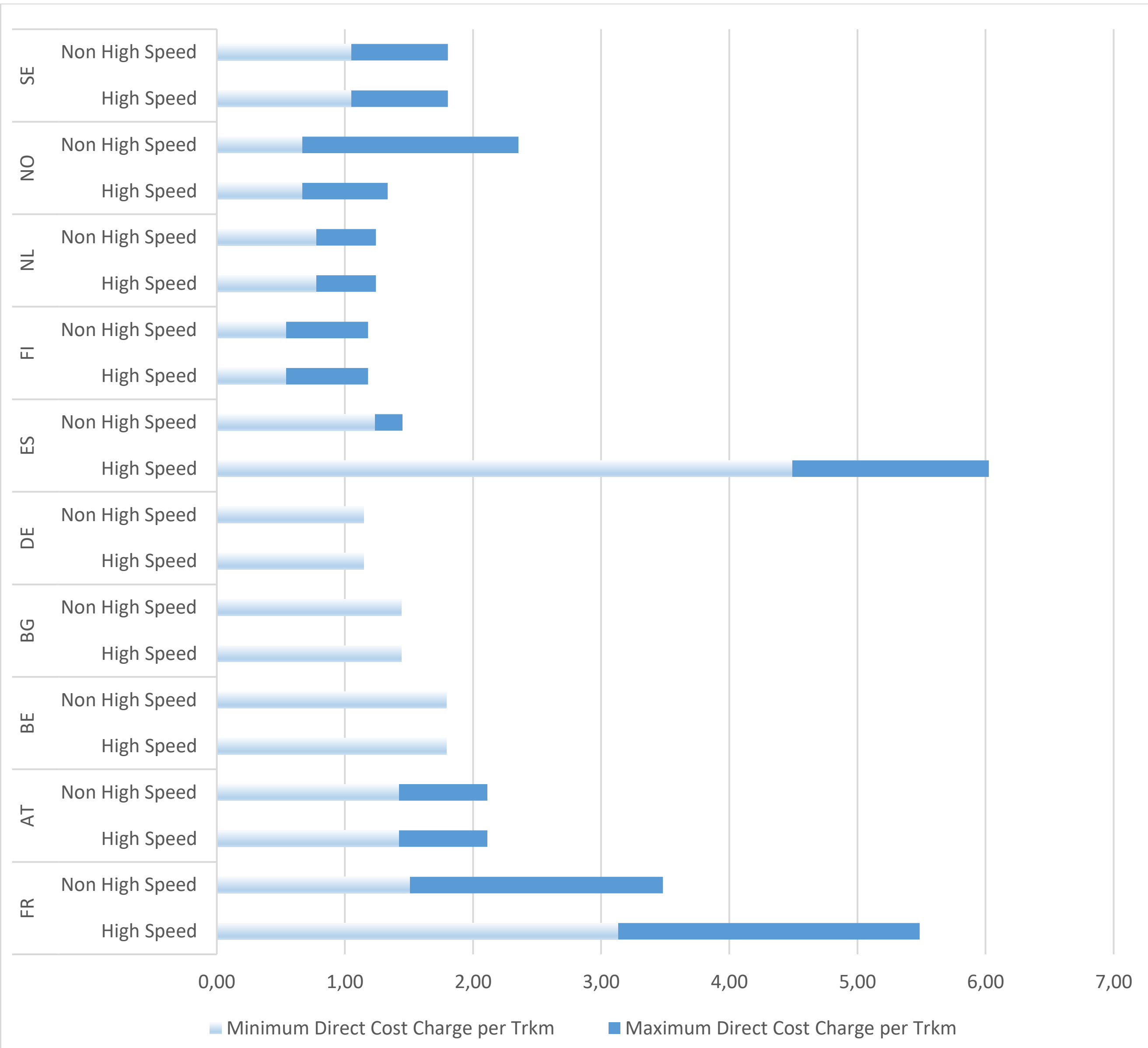
FIGURE 25: DIRECT COST CHARGE FOR LONG DISTANCE NON-PSO SERVICES PER TRKM BY WEIGHT FOR 2022



High speed

According to the data gathered, France, Norway and Spain make a distinction between high speed and non-high speed trains for long distance (non-PSO). Interestingly, some others like Germany and Belgium with considerable high speed services do not make a distinction. One would have expected speed to be a major factor to impact the calculation of direct cost per train km. In Norway long distance high speed services cross from “Oslo local” to “other sections” and do not fall into the more expensive direct cost charge category. Therefore, the charges are lower than for non-high speed services that passing through other more expensive sections. In Germany, the same direct costs charge applies to all long distance non-PSO services, so that there is no difference.

FIGURE 26: DIRECT COST CHARGE FOR LONG DISTANCE NON-PSO SERVICES PER TRKM BY SPEED FOR 2022



8. Practical Problems

A series of practical issues regarding the calculation of direct cost have been identified by IRG-Rail RBs. The issues concern both econometric and engineering methodologies.

A first strand of practical problems concerns the availability and quality of data used for such estimations. Regarding engineering estimations, Germany for instance underlined that the current bookkeeping system of its IM contained too many transactions and cost positions in the cost block "maintenance". This affected the practicability of the calculations. To enable experts to assess their relevance for direct cost calculation, these transactions and positions had to be clustered into more aggregated cost positions.

Another practical problem when using an econometric approach is related to the way accounting costs are allocated to the segments of the network that are used as the units of observation that feed into the econometric model. It may be the case that the allocation of costs is not made directly to the rail section but rather based on key drivers. Therefore, it distorts the existing relationship between costs and the level of use of the infrastructure. Also, some bookkeeping adjustments based on accounting rules could affect the relationship between actual costs and traffic.

Another strand of practical problems lies in the fact that no turnkey solution can be provided for engineering or econometric methodologies. Indeed, both methodologies have to be tailored to fit national specificities. Regarding engineering methods, this can for instance be seen in the fact that each IM has its own bookkeeping system and that transactions and booking positions will necessarily vary from one country to another, thus preventing the definition of a single methodology to deal with these issues. As for econometric methodologies, the absence of a turnkey solution is due to the fact that the choice of control variables or functional form will depend both on the type and quantity of data available as well as on the national characteristics of the network.

Closely related to the lack of turnkey solutions, a final strand of practical problems identified by some IRG-Rail RBs relates to the level of expertise needed to master the calculation of direct cost using these methodologies. This issue may concern both IMs and RBs who are respectively given the task of applying and reviewing one of these methodologies. For some IMs or RBs, the required expertise may not necessarily be available in house. In such cases, the actors may call on the assistance of an outside and independent consulting firm or expert to guide their respective tasks regarding the estimation of the directly incurred cost.